A SYSTEM OF ORTHOPAEDICS AND FRACTURES

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By

A. GRAHAM APLEY

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PREFACE

For many years a course in orthopaedics and fractures, designed primarily for F.R.C.S. candidates, has been held at Pyrford. As the course grew and developed, so did the desire to cover the field as comprehensively as possible. Eventually, as a prophylactic against writer's cramp, lecture notes were issued. Re-written and amplified, these form the basis of the present book. The aim has been to prepare a text comprehensive enough for postgraduates, yet simple enough for undergraduates.

Many students, whether postgraduate or undergraduate, are not lacking in factual knowledge so much as in a methodical approach. The presentation used is designed to overcome this handicap and to inculcate method. Physical signs are described in a constant sequence throughout and, as far as possible, a standard system of headings is used both for orthopaedic disorders and for fractures.

In practice the same doctor usually deals with orthopaedics and with fractures; and rightly so, for they share many principles in common. Consequently a book dealing with both subjects may be appropriate and convenient. To this end brevity was important. I have tried to avoid wordiness and to present facts concisely. Illustrations have not been included; their value is not denied but, if the reader keeps the patient constantly in mind, and punctiliously follows the precept of "LOOK, FEEL, MOVE", illustrations should not be indispensable. Their absence has been accepted as a challenge to provide unambiguous verbal descriptions instead.

The combination of method and compactness will, it is hoped, help the busy house surgeon, casualty officer, or the doctor who only occasionally practises orthopaedics, to find his way quickly in a large and complex subject.

In preparing this book I have leaned heavily on others. Many of their ideas have made such instant appeal that I have absorbed them and can no longer recall their source or adequately acknowledge my indebtedness. An immeasurable debt is, however, due to my teacher George Perkins, whose influence has, I hope, pervaded both my work and my teaching.

On many occasions I have sought the help of my colleague Mr. F. A. Simmonds, who has never failed to give sound advice. I am greatly indebted to Dr. I. Churchill-Davidson for his ungrudging and detailed help in writing the sections on radiotherapy. Mr. Gordon Hadfield read through the entire text and his many valuable suggestions are deeply appreciated. It is a pleasure to pay tribute to the diligence and skill of my secretary, Miss L. Freeland, and to acknowledge the constructive suggestions and friendly co-operation of the publishers.

January, 1959

A. GRAHAM APLEY

CHAPTER 1

DIAGNOSIS IN ORTHOPAEDICS

AN orthopaedic disorder does not exist in isolation. It is part of a patient who has a personality, a mind and a body; a job and hobbies; a family and a home. Any of these factors may have an important bearing upon the disorder and its treatment. They will not be considered at length, but are stressed here as they should be at the beginning of any clinical examination. It would also be out of place to discuss in detail the symptoms and signs of general illness in patients with orthopaedic disorders. Their importance is obvious, and in subsequent chapters they take pride of place before the symptoms and signs of local disorder.

Orthopaedics is concerned with disorders of bones, joints, muscles, tendons and nerves. The field is wide, yet limited. When a diagnosis appears elusive it is sometimes helpful to review the pathological entities likely to be encountered. They fall into easily remembered pairs: injury and inflammation; tumour and degeneration; muscle weakness and mechanical derangement; congenital deformity and acquired dystrophy.

SYMPTOMS

A thorough history demands patience. Unless the doctor allows the patient to tell his story more or less in his own way, important facts may be missed and the patient feel justifiably aggrieved.

The common symptoms in orthopaedics fall into three groups. The patient may complain that something looks wrong (deformity, shortening, swelling or a lump); that something feels wrong (pain or numbness); or that movement is wrong (limp, weakness, flailness, stiffness or mechanical derangement). Pain, local or referred, is the most common and important symptom.

Although the patient must be allowed to tell his own story, he needs guidance. Of any particular symptom it may be necessary to enquire if the onset was sudden or gradual, or preceded by injury or illness; if it is constant or intermittent, static or increasing, and whether anything makes it better or worse; finally, the occupation and any old illness or injury may be important.

LOCAL SIGNS

For examination, a patient must be suitably undressed. No mere rolling up of a trouser leg is sufficient. Where one limb is to be examined, the opposite one must be adequately exposed, so that the two may be compared. The sequence of examination is: to look at, to feel and to move the affected part.

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LOOK —

Skin — The colour of the skin is noted, as well as any scars or sinuses.

Shape — Limb deformities may be symmetrical or multiple; if so, the cause is usually a general disorder. One limb as a whole may be too short or too long, too thin or too wide. Shortening may involve a part or the whole of a limb and will be considered later.

A joint may be swollen; if so, the swelling may be confined within the synovial membrane (for example, an effusion or haemarthrosis) or extend beyond it (for example, in rheumatoid arthritis).

Muscles may be wasted.

A localized swelling or lump may be visible.

A bone may be bent; if so, the bend may be a gradual curve (for example, due to bone softening) or sharply angular (for example, after injury).

Position — In joint disorders the limb is often held in an abnormal position; and in nerve lesions a characteristic attitude may be adopted.

FEEL —

Skin — The skin may feel too cold (for example, in trophic conditions), or too warm (for example, with inflammation or a malignant tumour). Local warmth is usually estimated by comparing the two opposite limbs; but Perkins' method, in which the affected limb is felt by stroking it from proximal to distal end, is more reliable. Normally the temperature is uniform or diminishes steadily, an interruption in the normal gradient is easily perceptible. Sensation may be altered or absent; if so, the area affected is mapped out.

Soft tissues — A joint is examined for tenderness, synovial thickening or increased fluid. Synovial thickening feels somewhat fluctuant and the edge is easily palpable; an effusion is obviously fluctuant and the edge not palpable. Blood in the joint feels doughy. These signs can be elicited only in superficial joints (for example, the knee, ankle, elbow, wrist).

Muscles are palpated to determine their bulk and tone, and for local tenderness. Muscle bulk diminishes if injury is followed by disuse, if the muscle is paralysed, or if its action produces movement at an inflamed or painful joint. Muscle tone in the normal resting state is decreased with lower motor neurone lesions (in which the flabby feel is often characteristic) and increased in upper motor neurone lesions. In addition, spasm of muscle may guard against painful joint movement. Localized tenderness is present after a partial tear.

A tendon or nerve may be palpably thickened or may be tender.

Lumps are felt for tenderness, for pulsation, and to determine their size and shape, edge and attachments, consistency and contents.

Bones — A bone is felt for tenderness, to estimate its width and to find any localized thickening or lump

The bony components of a joint are felt for tenderness and to decide if they are in their correct relationship to one another.

MOVE —

Joint range — Active movement at a joint may be limited or painful. Limitation in all directions occurs if a joint is inflamed or the capsule fibrosed. Limitation in only one direction usually indicates a mechanical disorder.

Passive and active movements are compared. If the active range is less than the passive, a muscle is torn, paralysed, or reflexly out of action.

Abnormal movements are tested If there is excess movement in all directions and such movement is painless, the joint is neuropathic (for example, in Charcot's disease). Increased movement in only one direction occurs if a ligament is completely torn.

Muscle action — The patient is asked to perform a movement which puts a particular muscle into action, and the surgeon resists the movement while feeling the muscle. If the muscle is paralysed or torn, no contraction occurs; in the presence of active joint inflammation the muscle only tautens feebly; and with a partial tear, muscle action against resistance induces local pain.

Bone — When a bone is being examined, movement at the neighbouring joint should always be tested. The integrity of the bone itself should also be tested; unless the bone moves in one piece there is a fracture, and non-union is surprisingly often missed.

Function — With the upper limb the patient is asked to perform familiar actions; weakness, clumsiness, limitation of movements or pain is noted.

With lower limb disorders the patient is asked to lift his leg, to stand on it, to walk, run and if necessary to hop; weakness, limp or pain is noted.

NOTE — In addition to looking, feeling and moving, it is often necessary to examine the function of the limb as a whole and sometimes measurements are required.

If a limb is short, the shortening is measured with a tape measure or by placing blocks under one foot until the pelvis becomes horizontal.

If a limb is thin it is sufficient for most clinical purposes merely to state if wasting is slight, moderate or severe; circumferential measurements may, however, be necessary to decide if wasting is progressive, and are required for legal purposes.

I: X-RAY EXAMINATION

A careful study of x-ray films is indispensable in orthopaedics. The minimum requirement is two views of the affected area: antero-posterior and lateral. Occasionally oblique views are valuable. Often it is necessary to compare films of two limbs and, where bone density is important, these should if possible be taken on one x-ray plate. Occasionally, as with dystrophies and tumours, other parts of the body need to be x-rayed. Special techniques, such as tomograms, stereoscopic views and the injection of radio-opaque substances, are sometimes helpful.

X-ray films should be inspected in a methodical way. The account which follows is intended, not for a first reading, but to show the pattern of examination, and for reference.

X-RAY OF A BONE

GENERAL APPEARANCE OF THE BONE AS A WHOLE

Shape — The whole bone may be: too wide (for example, Paget's disease, page 57); bent (for example, bone deformity, page 6), squashed irregularly (for example, Kienboch's disease, page 42).

Density — The whole bone or several bones may be too dense or too rare.

Increased density — This may involve all the bones (for example, marble bones, page 49) or only one small bone (for example, Köhler's disease, page 242).

Decreased density — This is much more common and is described by a wide variety of terms. It is convenient to distinguish the following conditions.

(*a*) Osteomalacia, in which there is deficient calcification of osteoid tissue, so that the trabeculae are of normal width but low density. It occurs with deficiency of calcium or vitamin D, or both (*see* rickets, page 52).

(*b*) Osteoporosis, in which bone formation is reduced or absorption increased, so that the trabeculae are fewer and thinner. The causes are: disuse, especially following immobilization or paralysis; endocrine abnormality, especially in senility and in climacteric or post-menopausal osteoporosis. Less common endocrine causes are: increased secretion of the adrenals (Cushing's syndrome) or the parathyroids (von Recklinghausen's disease).

(*c*) Rarefaction, which is sometimes regarded as a special variety of osteoporosis. The term rarefaction is used, however, when there is a local inflammatory cause such as tuberculosis.

Architecture — The structural pattern of the bone as a whole is altered in the following conditions.

(*a*) Chronic osteomyelitis, in which widespread areas of increased density are interspersed with rare areas (*see* page 13).

(*b*) Paget's disease, in which the trabeculae are coarse, dense and too far apart (*see* page 57).

(*c*) Fibrous dysplasia, in which the trabeculae are replaced by longitudinal strands of calcification and there are also scattered translucent areas.

(*d*) Osteopathia striata, where the bones appear striped (*see* page 50).

(*e*) Haemangioma, where the bone has a soap-bubble appearance (*see* page 65).

LOCAL ABNORMALITIES OF INDIVIDUAL COMPONENTS OF BONE

Periosteum — Except in premature and young infants, the periosteum is not seen on x-ray unless it is abnormal. The conditions in which it may be seen are as follows.

Injury — After a fracture, callus forms. Even without a fracture a subperiosteal haematoma may calcify

Inflammation — In acute osteomyelitis, the stripped-up periosteum shows as a fine line separated from cortex by a translucent line. In chronic pyogenic osteomyelitis the new periosteal bone is irregular and blends with the cortex. In syphilitic infection periosteum may be thickened over more than one area.

Tumour — Osteogenic sarcoma may show striations at right angles to the shaft (sunray spicules) and a triangular shadow where the raised periosteum joins the normal (Codman's triangle) In Ewing's tumour striations are seen outside the cortex and parallel to the shaft.

Cortex — The cortex may be too thick, too thin, or perforated.

Too thick — In Paget's disease, thickening extends over a wide area. An osteoid osteoma shows localized dense thickening

Too thin — A benign tumour or cyst may balloon the cortex from within. The pressure of a fibrosarcoma or aneurysm may thin the cortex from without

Perforated — The cortex may be irregularly eroded or perforated by acute inflammation, syphilitic osteitis, or a malignant tumour

Medulla — The medulla may contain one or more areas of altered density.

A single rarefied area — This may be due to one of the following conditions.

Inflammation, for example, a Brodie's abscess, which has a sclerosed margin and is often lobulated.

Solitary cyst, which has a well-defined but not sclerosed margin and is situated on the shaft side of an epiphyseal line.

Benign tumour: a chondroma usually shows specks of calcification and occurs in short bones; a giant-cell tumour is often trabeculated and at the very end of a long bone; both have a clearly defined edge.

Malignant tumour: an osteolytic sarcoma or myeloma has no well-defined edge.

Multiple rarefied areas — These may be due to one of the following conditions.

Fibrous dysplasia: cysts occur in one or several bones.

Cystic deposits, which occur in hydatid disease and the lipoid dystrophies (for example, Gaucher's disease).

Malignant disease. multiple deposits occur in carcinomatosis and myelomatosis.

A single area of increased density — This may be due to one of the following conditions.

Aseptic necrosis, which may follow trauma or occur without obvious cause.

Septic necrosis: a sequestrum is dense, probably because of avascularity.

Tumours: increased calcification may occur in a benign tumour (for example, chondroblastoma) or in part of an osteogenic sarcoma.

Multiple areas of increased density — These may be due to one of the following conditions.

Engelmann's disease: in this rare condition bands of sclerosis occur and are symmetrically situated in the major long bones.

Tumours: with prostatic carcinoma patchy deposits of sclerosis may occur.

NOTE — The tissues outside the bone may also show abnormalities. Calcification may occur in a haematoma (myositis ossificans), a cold abscess, or an area of avascular tendon (for example, in the supraspinatus). Undue translucence in the soft tissues is seen with a lipoma.

X-RAY OF A JOINT

Density of bones — The general density of the bones is noted. It is reduced as compared with the opposite side in chronic inflammatory disorders (for example, tuberculosis) and after disuse.

The joint itself

Position — The joint may be dislocated, subluxed or in a position of deformity.

Joint space — In chronic inflammation (for example, rheumatoid arthritis) the space is uniformly decreased. In osteoarthritis the decrease occurs chiefly where pressure is transmitted, and there may be lipping or osteophytes at the edges.

The joint space is increased in some varieties of osteochondritis (for example, pseudocoxalgia) and occasionally when a joint is distended with fluid.

Joint line — In chronic arthritis (for example, in tuberculosis) the articular surfaces are irregularly eroded. In osteochondritis dissecans a crater is seen on one convex surface.

The bones — The bones above and below the joint are systematically examined as already described.

NOTE — There may also be loose bodies within the joint or calcification in soft tissues outside it.

II: SPECIAL PROBLEMS

In this section certain important clinical features are selected for further consideration.

BENT BONES

The long bones are straight or have slight natural curves. If a bone is abnormally bent it must have broken, or been soft at some time, or have grown faultily.

If several bones are bent, the likely causes are multiple injury (for example, to brittle bones) or a general bone-softening disease (such as rickets, Paget's disease or senile osteoporosis).

A SINGLE BENT BONE

A single bent bone may be due to one of the following causes.

Injury — A mal-united fracture of the shaft of a bone usually results in a sharp angular curve. A crush fracture to the end of a long bone is liable to result in deformity at a joint.

Bone softening — Paget's disease, unlike rickets, may affect only a single bone. The whole bone has a gradual curve and the bone is thick.

Faulty growth — Part of an epiphysis may be damaged by injury or by an adjacent tumour or inflammatory process Surprisingly, fracture-separation of an epiphysis hardly ever affects growth, whereas an apparently minor epiphyseal crush may do so. Rarely, growth is stimulated by local hyperaemia.

A BENT TIBIA

The common causes of a bent tibia (other than mal-union of a fracture) are as follows.

Rickets — Near its lower end the tibia bends backwards and inwards. Both tibiae are symmetrically affected.

Paget's disease — The curve is uniform over the whole bone, and the bone is too thick. Often only one tibia is affected.

Syphilitic osteitis — The tibia is not really curved, but has new periosteal bone laid down on its anterior border, so that it looks bent (sabre tibia). The posterior border remains straight.

JOINT DEFORMITY

Strictly speaking, a deformed joint is one which is mis-shapen. By custom, however, the meaning is widened to include a joint held in an abnormal attitude.

A mobile deformity is one in which the normal anatomical position can be restored by the efforts of either the patient or the doctor.

A postural deformity is one which the patient himself can, if properly instructed, correct by his own muscular effort.

A fixed or structural deformity is one in which a joint cannot be restored to its anatomical position without anaesthetic or operation.

An idiopathic deformity has no known cause; examples are scoliosis, knock knee, flat feet.

Hysterical deformity is usually gross and should not be diagnosed unless other causes of deformity have been excluded and other stigmata of hysteria are present.

CAUSES

Deformities affecting many joints may be due to congenital disorders (an example is chondro-osteodystrophy), or to acquired disease (especially rheumatoid arthritis).

In deformity of a single joint or localized group of joints, it is often possible to identify the responsible factor, which may be one of the following.

Skin — Contracture (for example, after a burn, operation or injury) may limit movement and produce deformity.

Fascia — This is rarely a cause of joint deformity, but in Dupuytren's contracture fibrosis of the palmar fascia pulls the fingers into fixed flexion (*see* page 143).

Muscle — Paralysis, spasm or fibrosis may lead to joint deformity.

Unbalanced paralysis may, if a strong muscle is unopposed, pull a joint into a deformed position. Peripheral nerve lesions give characteristic deformities but usually the deformity is not fixed and is essentially an abnormal attitude. After poliomyelitis, deformity due to unopposed muscle action often becomes fixed.

Prolonged muscle spasm occurs with chronic joint inflammation and stronger muscles gradually overcome weaker; thus an old tuberculous hip becomes flexed and adducted. Deformities in spastic paralysis are similarly due to stronger muscles overcoming weaker.

Shrinkage of fibrosed muscle is the cause of contracture following Volkmann's ischaemia. For example, if the forearm muscles have contracted the fingers are held flexed and can only be straightened by flexing the wrist, thus allowing the muscle to "pay out".

Tendon — Division, especially in the hand, may lead to deformity (*see* pages 141–142) and deformity may also result from adhesions within a tendon sheath (*see* page 142).

Ligaments — These may be overstretched permitting such deformities as knock knee or flat feet. In Charcot's disease deformity is associated with gross ligament laxity.

Capsule — Fibrosis occurs in osteoarthritis, producing fixed deformity. If the deformity prevents a movement which is constantly being required (for example, extension at the hip), then minor capsular tears occur with further fibrosis and increasing deformity.

Bone — Abnormality (*see* Bent Bones) may produce deformity at or near a joint; and faulty position of the bones (that is, dislocation or subluxation) is an obvious cause of deformity.

SHORTENING

Shortness of stature (dwarfism) may be due to short limbs (as in achondroplasia), a short trunk (as in severe scoliosis or kyphosis), or to short limbs and a short trunk (as in diaphyseal aclasis or in brittle bones).

Shortening of only the upper limbs is rarely a problem in orthopaedics, but shortening of the lower limbs often is. Bilateral shortening of the lower limbs, because it is symmetrical, is rarely a symptom. It occurs with bilateral hip dislocation or infantile coxa vara.

Shortening of the whole of one lower limb — The whole of one limb, that is, both femur and tibia, may be short. As a rule the leg is also thin and the foot small. Causes [illegible]

[illegible] bifida; and paralysis,

Shortening of part of one lower limb — Part of one limb may be short. As described in the chapter on the hip joint, the shortening is analysed and measured in three stages.

Is it real, or apparent, or both?
Is it above or below the knee?
Is it above or below the great trochanter?

Above the great trochanter — Here shortening may be due to one of the following disorders.

Hip joint dislocation (congenital or pathological), or fixed deformity (giving apparent shortening)

A femoral head which has been flattened (by pseudocoxalgia), or destroyed (by tuberculosis, which may give gross shortening)

In the upper epiphysis, coxa vara (infantile or adolescent).

In the femoral neck, coxa vara (due to a mal-united trochanteric fracture), non-union of a transcervical fracture, or bending of soft bone (rickets or Paget's disease).

Below the great trochanter — Here shortening may be due to one of the following disorders.

In the femoral shaft, congenital abnormalities, bending of soft bone (rickets, Paget's disease or fibrous dysplasia), mal-union of a fracture, or epiphyseal arrest.

In the tibia the causes are the same as in the shaft of the femur.

STIFFNESS OF A JOINT

The term "stiffness" is used to cover a wide variety of limitations of movement. It is convenient to consider three grades, as follows.

All movements absent — Complete absence of movement may result from a suppurative arthritis in which articular cartilage has been destroyed and bony trabeculae cross the joint (bony ankylosis); or from operation (arthrodesis).

All movements limited — With active inflammation of synovium, extremes of all movements are limited and the joint is said to be "irritable". With active arthritis there is joint rigidity, spasm preventing all but a few degrees of movement.

A tuberculous arthritis heals by fibrosis, leading to an unsound joint in which forced movement is painful, and deformity may increase with time. The term "fibrous ankylosis" is used when fibrous tissue across the joint is so short that only a few degrees of movement exist. (Occasionally if the fibrous tissue is very short, the ankylosis is almost sound.) With longer fibrous tissue and more movement, the term "ankylosis" is best avoided and "long fibrous joint" is better.

In osteoarthritis the capsule fibroses and as the fibrous tissue matures it shrinks, limiting movement; usually, however, some movements are much more limited than others

In active rheumatoid arthritis movement at several joints may be limited in all directions by pain; subsequent fibrosis may perpetuate the limitation.

After severe injury, especially compound fractures near a joint, movement in all directions may be limited as a result of infection, adhesions, or loss of muscle extensibility.

Some movements limited — In certain conditions some movements are limited but movement in at least one direction is full and painless. The cause is usually mechanical. Thus a torn and displaced meniscus may prevent extension of the knee but not flexion.

Again, if one group of muscles acting on a joint is paralysed the opposing group eventually loses the ability to stretch fully and fixed deformity with stiffness in one direction results.

Bone deformity may alter the arc of movement, so that it is limited in one direction (loss of abduction in coxa vara is an example) but movement in the opposite direction is full or even increased.

BONY LUMPS

Multiple bony lumps are uncommon. They occur in diaphyseal aclasis as squat knobs of bone around one or several joints. In syphilis there may be two or more diffuse swellings on the shaft of a bone.

A single bony lump may be due to faulty development, injury, inflammation or a tumour. Although x-ray examination is essential, a diagnosis can usually be made clinically by considering the following factors.

Size — A large lump attached to bone, or a lump which is getting bigger is nearly always a tumour.

Site — A lump near a joint may be a cancellous osteoma (if small), an osteochondroma (if large), a benign giant-cell tumour (if ill-defined and at the very end of the bone), or a sarcoma (if ill-defined, tender and near the metaphysis). A lump in the shaft itself may be callus (which extends all round the bone), inflammatory (if tender and ill-defined), or a tumour such as Ewing's tumour.

Shape — A benign tumour sticks out from one aspect of the bone, malignant tumours or callus extend all round it.

Tenderness — Lumps due to active inflammation, recent callus or a rapidly growing sarcoma are tender.

Edge — A benign tumour has a well-defined margin; malignant tumours, inflammatory lumps and callus have a vague edge.

Consistency — A benign tumour feels bony hard, malignant tumours often give the impression that they can be indented. Occasionally a small ganglion or a cyst (for example, a cyst of the lateral meniscus) feels almost bony hard.

TUNNEL SYNDROMES

In a number of situations normal tendon action is impaired by thickening of the tendon sheath (stenosing tenovaginitis) or by a nodule in the tendon. The commonest examples are: trigger finger; de Quervain's disease; clicking thumb; and congenital flexion contracture of the thumb. In all of these there is insufficient room for tendon to glide smoothly through a fibrous tunnel.

Nerves also, where they cross joints, may be confined within fibrous tunnels. In three situations the tunnel may be too small: at the elbow, giving ulnar neuritis; at the wrist, giving median neuritis; and in the groin, giving meralgia paraesthetica.

All these tunnel syndromes may be cured by slitting the affected sheath.

CHAPTER 2

INFLAMMATION OF BONE AND JOINT

I: ACUTE PERIOSTITIS

PATHOLOGY

ACUTE PERIOSTITIS occurs only after trauma, such as a kick on the shin. A subperiosteal haematoma forms and may become infected; later the unabsorbed portion may calcify.

SIGNS

A few days after an injury the patient has a raised temperature.

LOOK — A fusiform swelling may be visible.

FEEL — If there is a swelling it is warm, tender and fluctuant.

MOVE — Attempted angulation is painless and, unlike a fracture, the bone moves in one piece.

X-RAY — At first the appearance is normal; after about 10 days the periosteum becomes visible and is thickened.

TREATMENT

The limb is rested on a splint and the patient given analgesics and antibiotics. A large haematoma or abscess should be aspirated and incision is only necessary if the condition does not then subside.

II: CHRONIC PERIOSTITIS

Periosteal thickening occurs beneath a chronic ulcer. Apart from this there are only two varieties of chronic periostitis.

FOLLOWING ACUTE PERIOSTITIS — A haematoma following trauma or acute periostitis may ossify, leaving bone which is thickened on the surface (the knobbly shins of a footballer is an example). X-rays, however, show that the deep aspects of the cortex and the medulla are normal.

Following acute osteomyelitis, new subperiosteal bone is laid down. The term "chronic periostitis" is then best avoided, for all layers of the bone have been involved in a process of irregular sclerosis

CHRONIC FROM THE START (SYPHILITIC PERIOSTITIS) — Spirochaetes carried by the bloodstream may be deposited in bone. Cellular infiltration is succeeded by fibrosis. Subsequently, because of obliterative endarteritis the bone locally becomes avascular, with characteristically dense sclerosis.

Multiple nodes — Multiple tender periosteal nodes may occur in subcutaneous bones during the secondary stage.

Localized — Localized periostitis (one or more gummata) may occur, also in subcutaneous bones, during the tertiary stage. There is a smooth, hard swelling and x-rays show a very dense superficial node on the bone. Later the centre may necrose and the overlying skin break down, leaving a punched-out ulcer with a yellow slough covering bare bone.

Diffuse — Diffuse periostitis occurs most commonly in the tibia and may be bilateral. The periosteum is irregularly thickened on both its superficial and deep aspects. Clinically the bone appears to be bent, but x-rays show that only the front is thickened, the posterior border remaining straight ("sabre tibia").

DIFFERENTIAL DIAGNOSIS

In all cases of chronic periostitis the patient's Wassermann reaction must be determined and, if doubt persists, a biopsy is necessary.

Localized periostitis must be differentiated from the following conditions.

EWING'S TUMOUR (*see* page 69) — In this condition new periosteal bone is laid down in layers parallel to the shaft. The clinical and radiological features usually subside rapidly with radiotherapy, but biopsy may be necessary.

OSTEOID OSTEOMA (*see* page 62) — In this tumour a localized area of cortical thickening is present. Unless a clear central area (the nidus) can be seen on x-ray, biopsy may be necessary.

Diffuse periostitis must be differentiated from other causes of a bent tibia, namely old rickets and Paget's disease.

OLD RICKETS — This is always bilateral, the curve is in the lower quarter in two planes and the bone is not thick.

PAGET'S DISEASE — The bone is thick and bent; in this condition, unlike sabre tibia, the posterior border also is bent.

III: ACUTE OSTEOMYELITIS

CAUSE

The causal organisms are usually staphylococci, though in young children streptococcal infection is not uncommon. Occasionally pneumococci, organisms of the typhoid-salmonella group or even brucellosis may be responsible.

The bloodstream is invaded usually from a minor skin abrasion, rarely from a boil. In children the organisms nearly always settle in the metaphysis at the growing end of a long bone, possibly because: (*a*) the rapidly growing cells are unduly susceptible; (*b*) the delicate vessels have been injured and the haematoma is a suitable medium

for bacterial growth; or (*c*) the hairpin arrangement of capillaries has slowed down the rate of blood flow. In adults the shaft may be attacked.

Bone may be infected directly from a wound, but usually this does not present as acute osteomyelitis, because the path of infection also provides a route for drainage.

PATHOLOGY

SUPPURATION — Pus forms within the medulla and, being in a confined space under tension, forces its way along the Volkmann canals to the surface of the bone. It then spreads subperiosteally, both around the bone and along the shaft. Pus may re-enter the bone at another level, or burst out into the soft tissues. The growth disc and joint capsule are rarely penetrated.

NECROSIS — Bone dies when its blood supply is cut off by rising tension within bony walls, infective thrombosis, or the stripping up of the periosteum. Dead bone becomes dense, and pieces may separate as sequestra which act as foreign-body irritants, causing persistent discharge through a sinus until they escape or are removed.

NEW BONE FORMATION — New bone forms from the deep layer of the periosteum. If bone formation is extensive, it constitutes an encasing involucrum which may contain holes (cloacae).

SYMPTOMS

A history of a preceding skin lesion or of an injury may be obtained. A few days later there is rapid onset of fever and malaise and of pain. The pain is localized, unrelieved by rest and often severe.

SIGNS

The patient, usually a child, is ill and toxaemic, with a rapid pulse and high fever. There is leucocytosis and a positive blood culture. The local signs are as follows.

LOOK — The limb is held still It looks normal at first but later swelling and redness may appear.

FEEL — If the child allows the limb to be touched, localized "finger-tip" tenderness is felt over a metaphysis, and later warmth and oedema.

MOVE — The child may not permit movement of the limb Usually the neighbouring joint, though irritated, has at least a few degrees of painless movement

X-RAY — For the first 10 days x-rays show no abnormality. Later there is patchy rarefaction of the metaphysis, and periostitis which shows as a thin line parallel to the shaft

Later still, as healing occurs, there is sclerosis and new periosteal bone; sometimes sequestra are seen, which are very dense and separated from the surrounding bone.

DIFFERENTIAL DIAGNOSIS

In acute suppurative arthritis tenderness is diffuse, and all movement at the joint is abolished.

In acute rheumatism the pain tends to flit from one joint to another, and there may be carditis, rheumatic nodules or erythema marginatum.

With a fracture there is no fever, and x-rays show the fracture line.

TREATMENT

ANTIBIOTICS — This heading is put first to emphasize the importance of the prompt administration of antibiotics. Crystalline penicillin (1 million units) is injected intramuscularly as soon as even a provisional diagnosis is made; then half a million units twice a day for at least 5 weeks. If the symptoms and signs do not rapidly subside the antibiotic is changed; to determine the most effective antibiotic the organisms obtained from aspiration or blood culture are tested for sensitivity.

SPLINTAGE — A splint is desirable but should not conceal the affected area. Often bed rest, possibly combined with traction, is sufficient. With acute osteomyelitis of the upper femur, traction is essential to ensure that the hip does not dislocate.

DRAINAGE — If antibiotics are given early enough drainage is often not necessary. If a subperiosteal abscess can be detected, or if pyrexia and local tenderness persist for more than 24 hours after adequate antibiotics, the pus should be let out by aspiration or incision; it should be cultured and tested for sensitivity. Only rarely, and especially if antibiotics are given too late, is it necessary to drain the bone itself.

COMPLICATIONS AND SEQUELS

Nowadays, with antibiotics, the child nearly always recovers and the bone may return to normal. If treatment is delayed or the organism proves insensitive to antibiotics the following complications may occur.

SEPTICAEMIA — This may occasionally prove fatal.

METASTATIC INFECTION — This may involve other bones, joints, serous cavities or lung.

SUPPURATIVE ARTHRITIS — This may occur (*a*) in very young children, in whom the growth disc is not an impenetrable barrier; (*b*) where the metaphysis is intracapsular, as in the upper femur; or (*c*) from metastatic infection.

INCREASED LENGTH OF BONE — This occasionally follows the metaphyseal hyperaemia.

CHRONIC OSTEOMYELITIS — This is much the commonest sequel (*see* below).

IV: CHRONIC OSTEOMYELITIS

CHRONIC OSTEOMYELITIS AS THE SEQUEL TO ACUTE OSTEOMYELITIS

PATHOLOGY

An area of bone has been destroyed by the acute infection; cavities are therefore present and are surrounded by dense sclerosed bone.

Bits of dead bone (sequestra) usually remain. They are imprisoned in fibrous tissue and sclerosed bone but may act as irritants, provoking the living tissue to produce serum. This serum escapes through a sinus which tends to persist because the sequestra cannot escape.

Bacteria also are imprisoned in fibrous tissue, where they often remain dormant for years, but at any time infection may flare.

CLINICAL VARIETIES

Perkins has described four sequels which may follow an infected gunshot wound of bone; the same sequels may follow acute haematogenous osteomyelitis.

PERSISTENT ACUTE OSTEOMYELITIS — This is extremely rare since the introduction of antibiotics. The patient's original acute illness does not subside and local inflammation with sinuses persists. If, despite antibiotics and wide drainage, the condition persists, amputation may be necessary.

SINUS — A sinus may persist because of sequestra, foreign bodies, or because the organisms are resistant. As with all forms of truly chronic osteomyelitis, x-rays show areas of bone rarefaction surrounded by dense sclerosis, and sometimes sequestra.

Treatment is usually conservative because the discharge may be no more than a nuisance, and a dry dressing protects the clothing. Antibiotics alone rarely help, for they cannot penetrate the barrier of fibrous tissue and sclerosis; they are useful as an umbrella if operation is undertaken.

Sequestrectomy is worthwhile only if x-rays clearly show a sequestrum and Lipiodol injection demonstrates that the sinus track leads to it. Often the sinus fails to heal because dead tissue is left behind If the discharge is copious and stinking, opening the sinus track widely is occasionally of value.

Attempting to excise diseased bone completely is a drastic procedure which hardly ever succeeds, even if unhealthy skin has first been replaced by grafts.

FLARES (RECURRENT ACUTE OSTEOMYELITIS) — At any time, even as long as 50 years after apparent healing, the bacteria may escape from their fibrous prison and the wound flare. The patient becomes feverish but not very ill or toxic. There is local pain, redness and tenderness.

Treatment is usually unnecessary because the flare subsides after a few days' rest. The patient expects to be given antibiotics but their value is doubtful. Occasionally an abscess forms; if it discharges spontaneously there is immediate relief, but if it remains painful and is superficial it should be incised.

SINUS WITH RECURRENT FLARES — Frequently-repeated flares and a constant smelly discharge may render the condition and even the limb itself an intolerable nuisance, in which case amputation may be necessary.

CHRONIC OSTEOMYELITIS OF INSIDIOUS ONSET

There are four varieties of chronic osteomyelitis which appear to be chronic from the start:

BRODIE'S ABSCESS — A Brodie's abscess is usually small and situated in the metaphysis of a long bone, though it may be of any size and occur anywhere in the bone. Clinically it may remain silent for years, or present with recurrent attacks of pain. During an attack the bone is tender and there may be a little swelling. X-rays show a translucent area with a well-defined margin and a small area of surrounding sclerosis, beyond which the bone looks normal

Treatment is operative Under antibiotic cover the abscess is opened. Rarely it

contains pus, but *usually clear sterile fluid*. The abscess wall is removed and the wound sutured.

TUBERCULOUS OSTEOMYELITIS (*see also* Chapter 4) — This is a chronic infection which as a rule remains clinically silent until it presents as: (*a*) a joint inflammation, from irritation or eruption into a nearby joint; (*b*) deformity, from collapse of soft bone, as in the spine; (c) swelling, possibly of the bone itself (as in dactylitis) or a cold abscess.

X-rays show an area of bone destruction with ill-defined margins and surrounding bone atrophy, in contrast with Brodie's abscess.

SPIROCHAETAL OSTEOMYELITIS — Syphilis of bone is a rare tertiary manifestation, producing localized or diffuse lesions. Localized gummata may occur in any part of the bone, but are usually subperiosteal in subcutaneous bones, and the overlying skin may break down. Diffuse periostitis may cause a sabre tibia (*see* page 6). Diffuse osteomyelitis presents as an aching, tender bone, sometimes with sequestra and sinuses. In congenital syphilis, epiphysitis and dactylitis also occur.

In bone syphilis x-rays may show periosteal thickening and punched-out translucent areas in the midst of dense sclerosis. The lesions are often multiple. A Wassermann test is essential for diagnosis.

Treatment is directed to the underlying disease. Penicillin and iodides are given.

Yaws may produce bone lesions similar to those of syphilis. Several bones are usually affected. The main changes are periosteal new bone formation and areas of rarefaction in the cortex; sclerosis is less than in syphilis.

CHRONIC NON-SUPPURATIVE OSTEOMYELITIS (GARRÉ) — This condition is probably not an osteomyelitis but a benign tumour. The clinical features, x-ray appearance and response to treatment are the same as those of an osteoid osteoma (*see* page 62).

V: ACUTE SUPPURATIVE ARTHRITIS

CAUSE

The causal organisms are usually staphylococci, occasionally streptococci and, rarely, other organisms. The joint is invaded through a penetrating wound, by eruption of a bone abscess, or by blood spread from a distant site.

PATHOLOGY

PYARTHROSIS — When a bone abscess bursts into a joint, the joint becomes a bag of pus. For a time, however, synovium and cartilage may be little affected. —

SUPPURATIVE SYNOVITIS — This may be a sequel to pyarthrosis or the synovium may be infected directly from the bloodstream. In either event the synovium becomes acutely inflamed.

SUPPURATIVE ARTHRITIS — This, the most severe form, occurs if pyarthrosis or synovitis are unchecked. Infection spreads rapidly through the joint and the articular cartilage disintegrates and is removed by polymorphs. Pus may burst out of the joint to form abscesses and sinuses. Later, with healing, opposing surfaces may adhere (fibrous ankylosis); often, however, trabeculae grow across the joint (bony ankylosis).

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Treatment is operative Under antibiotic cover the abscess is opened. Rarely it

weight-bearing exercises. Gradually weight is taken and the splint is eventually discarded. At all stages the patient is carefully watched for signs of a flare.

If articular cartilage has been destroyed, the aim is to keep the joint immobile while ankylosis is awaited. Splintage in the optimum position (*see* page 102) is therefore continuously maintained, usually by plaster, until ankylosis is sound. The patient is allowed to get up, and, when the bone has recalcified, to take weight.

GONOCOCCAL ARTHRITIS .

Nowadays gonococcal arthritis is rare; the joint infection is probably blood borne. There may be synovitis, a purulent effusion sometimes containing gonococci, or, if treatment is delayed, destruction of articular cartilage.

Two varieties are described: (*a*) monarticular, which involves a large joint, is often suppurative and comes on as the acute gonorrhoea is subsiding; (*b*) polyarticular, which involves large or small joints, is rarely suppurative and may not begin until long after the acute urethral infection.

Acute gonococcal arthritis comes on with almost dramatic suddenness. Pain is agonizing and the joint swollen and hot. Recent urethritis suggests the diagnosis and joint aspiration confirms it. With prompt antibiotic treatment full movement is usually regained, though formerly bony ankylosis used to occur.

With less acute joint infection, treatment is liable to be delayed because the diagnosis remains unsuspected. If the cause of an arthritis is in doubt the urethra should be examined, a prostatic smear taken and a complement fixation test performed.

REITER'S DISEASE — Occasionally, non-gonococcal urethritis is accompanied by conjunctivitis and arthritis. This combination is known as Reiter's disease and is sometimes grouped with the collagen disorders. It soon recovers but may recur. Cortisone is sometimes used in treatment.

VI: ACUTE NON-SUPPURATIVE ARTHRITIS

Acute non-suppurative arthritis occurs in the following conditions.

GOUT — In this metabolic disorder uric acid is produced in excess and excreted inadequately. Crystals of sodium biurate may be deposited in bone (producing translucent "cysts"), in cartilage (producing chalky tophi in the ears or fingers), in bursae (producing bursitis at the knee or elbow), or in joints.

The joints mainly affected are in the fingers and toes, especially the hallux. Sodium biurate crystals are acutely irritating, and an attack of arthritis comes on rapidly. The joint is painful, red, swollen and hot and is held still. X-rays show small punched-out translucent areas under the cartilage. After repeated attacks a joint (especially the metatarsophalangeal joint of the hallux) may become osteoarthritic.

The diagnosis is established by the history of previous similar attacks, the situation of the arthritis, the x-ray appearance and the raised blood uric acid level. Recovery occurs in 3 weeks, but is speeded by colchicum, which, if given early, may abort the attack.

SYMPTOMS

There may have been a wound. Within a few days (sometimes only 48 hours) the patient rapidly becomes ill, with severe throbbing pain and swelling.

SIGNS

The patient is obviously ill with a rapid pulse and high swinging fever. The white cell count is raised and blood culture positive.

Many of the local signs can be elicited only in superficial joints.

LOOK — The skin looks red, the joint is held flexed and it is fusiformly swollen.

FEEL — The skin feels hot, there is diffuse tenderness and fluctuation.

MOVE — All movements are grossly restricted and often completely abolished by pain and spasm.

X-RAY — For the first 2–3 weeks the appearance is normal, then the bone shows widespread patchy rarefaction, and the joint space may be narrowed. With healing, the bone recalcifies; the joint space may remain narrow and irregular, or be completely obliterated and crossed by trabeculae.

DIFFERENTIAL DIAGNOSIS

In acute osteomyelitis tenderness is pinpointed to bone, and a little joint movement is permitted.

In rheumatic fever the pain is less severe and is eased by large doses of salicylates; the general signs of rheumatism may be found.

In acute non-suppurative arthritis there is less general illness and the local signs are much less severe.

IMMEDIATE TREATMENT

ASPIRATION — Under anaesthesia the pus is aspirated as soon as possible and the fluid replaced by penicillin. The pus is cultured and the organisms tested for sensitivity.

ANTIBIOTICS — In addition to the penicillin instilled into the joint, intramuscular injections are started immediately, the dosage being the same as in acute osteomyelitis (*see* page 13). The injections are continued for several weeks, a more effective antibiotic being substituted if tests so indicate.

SPLINTAGE — The joint must be rested either on a splint or in a widely split plaster. At the hip, traction is necessary, or the joint may dislocate.

NOTE — Formerly joints were widely drained and sometimes irrigated; even amputation was occasionally necessary With antibiotics these measures are hardly ever required.

TREATMENT OF THE AFTERMATH

Once the patient's general condition is good and the joint is no longer painful or warm, further damage is unlikely.

If articular cartilage has been preserved, the aim is to regain movement. Gentle and gradually increasing active movements are encouraged (not passive and never forced). The patient is allowed up wearing a splint which is taken off for non-

CHAPTER 3

RHEUMATOID ARTHRITIS

CAUSE

ORTHOPAEDIC SURGEONS tend to limit their viewpoint. Rheumatoid arthritis does not exist in isolation; it is part of a widespread disorder much better called "rheumatoid disease".

The cause of this common, important and crippling disease is not established; there may well be more than one cause. Emphasis on causes varies from year to year. Important factors may include endocrine, metabolic or nutritional disorders, abnormal "somatotype" and faulty response to emotional or physical stress. The focal sepsis theory is now discredited.

The general view is that rheumatoid disease is one of a group of disorders in which fibrinoid degeneration of collagen occurs. These disorders may be associated with dysfunction of the adrenal cortex, though the ultimate cause is conjectural.

Whatever the cause there is certainly a well-marked familial tendency.

JOINT PATHOLOGY

The soft tissues, both intra-articular and extra-articular, are the first to be affected by the inflammatory process, being invaded by lymphocytes and plasma cells. The synovial membrane in particular becomes hyperaemic, swollen and proliferated. Because the swelling and oedema also affect extra-articular soft tissues, the joint appears spindle-shaped and this appearance is accentuated by the considerable muscle wasting.

From the edges of the synovial membrane, inflammatory material spreads over the articular cartilage, which becomes thin (so that the joint space is reduced) and may in patches be eroded. The underlying bone becomes rarefied. Subsequent fibrosis perpetuates the loss of range and as the fibrous tissue shrinks, deformity may increase. Rarely, bony ankylosis may occur between eroded articular surfaces.

SYMPTOMS

(1) General ill-health and malaise are usual while the disease is in an active phase.

(2) Joint symptoms are pain, stiffness, swelling and deformity. These come on gradually, usually affecting small joints first, especially in the wrists and fingers. They get steadily worse and tend to spread symmetrically up the limbs to involve larger joints. Occasionally one or two large joints are affected first and the onset is more rapid.

ARTHRITIS COMPLICATING A FEVER — Arthritis may develop about 10 days after the onset of a fever, especially after scarlet fever, measles or pneumonia; or much later after abortus fever. An effusion develops in one or more large joints. Usually there is little more than a mild synovitis which recovers. Aspiration and antibiotics may be required.

A similar effusion, which quickly recovers, may develop 10 days after serum has been given.

VII: CHRONIC ARTHRITIS

There are three main varieties of chronic arthritis, each important enough to merit a separate chapter.

RHEUMATOID ARTHRITIS (Chapter 3) — Usually many joints are affected, especially small joints. Muscle wasting is considerable and the patient is unwell. X-ray films of an affected joint show rarefaction of bone and uniform decrease of joint space.

TUBERCULOUS ARTHRITIS (Chapter 4) — Usually only one joint is affected, often a large one. Muscle wasting is marked and the patient is sometimes unwell. X-rays show rarefaction of the bones and an irregular joint space.

OSTEOARTHRITIS (Chapter 5) — Usually only one or perhaps two joints are affected. Unlike the other varieties, osteoarthritis is not inflammatory, so that muscle wasting is slight and the patient is fit in himself. X-rays show no bone rarefaction, and diminution of joint space occurs only where pressure is borne.

Suggestions for further reading

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x-ray. The presumptive diagnosis is tuberculous synovitis, but biopsy may show the condition to be rheumatoid in nature, and other joints may later become affected, even after an interval of many years.

VILLOUS SYNOVITIS — This condition tends to affect one or both knees in women over 40 years. The synovium is enormously hypertrophied and falls into folds; when these are pinched between the bones they bleed and become pigmented. Diagnosis from rheumatoid arthritis is easy because in villous synovitis, despite gross swelling, there is little wasting and often surprisingly good movement. Synovectomy is only rarely indicated.

INTERMITTENT HYDROPS — This condition also affects one or both knees in women. At intervals the joint swells rapidly, then slowly subsides. The cause is unknown, but occasionally rheumatoid arthritis develops later.

SYPHILITIC ARTHRITIS — In this rare condition one or more large joints become swollen, usually without pain. The [illegible] bone erosion at the synovia [illegible] knees also occurs in congeni [illegible] Wassermann reaction establishes the diagnosis.

Note — Charcot's joints in syphilis are not due to spirochaetal invasion of the joints themselves, but are a sequel to tabes dorsalis. The joint degenerates because position sense and pain sense have been lost.

GENERAL TREATMENT

Rheumatoid arthritis (like tuberculosis) is a general disease with local manifestations. If the patient is ill, bed rest is necessary, but in rheumatoid disease a raised temperature is not in itself an indication for prolonged bed rest. Good food, fresh air, cheerful surroundings, constant care and attention and freedom from worry are ideal but rarely obtainable. Dietary fads are outmoded. The discovery and elimination of septic foci helps to pass the time while the disease burns itself out; possibly it also assists recovery.

DRUG TREATMENT

PAIN-RELIEVING DRUGS — Salicylates are the safest and probably the best drugs to use, especially in the form of soluble aspirin (5-grain tablets, dose in adults 40–100 grains daily). Compounds of aspirin with phenacetin and codeine are also useful, but prolonged administration of phenacetin is dangerous.

Phenylbutazone is sometimes effective, but may cause oedema, dermatitis or blood dyscrasias (100–200 mg. tablets, dose 400–600 mg. daily at first, gradually reducing).

SUPPRESSANT DRUGS — Steroids may produce considerable relief of symptoms and reduction of signs, occasionally in dramatic fashion. Such relief occurs only in 10–15 per cent of cases and even in these the disease is not cured but smoulders silently and may reappear when steroids are stopped. Often the drug is given the credit for a natural remission

Steroids are indicated when simpler measures have failed and the disease is active.

With remission, pain subsides and in mild cases the joints may return almost to normal. Sometimes, however, there is widespread crippling stiffness and deformity.

GENERAL SIGNS

The incidence of the disease is higher in women of the child-bearing age and falls after the menopause. It runs a long course, with exacerbations and remissions, eventually burning itself out after many years. During periods of activity the patient is unwell, often with fever and loss of weight. The sedimentation rate is raised, anaemia is common and lymph nodes are occasionally enlarged. These features subside during remissions, and the sedimentation rate is a useful index of activity.

A similar process in children was formerly called "Still's disease", but the term is being discarded in favour of "rheumatoid disease". Joint changes are the same as in the adult form of rheumatoid arthritis. The general illness is usually more severe and there is considerable anaemia. Sometimes there is enlargement of the spleen, and the heart may be affected.

In elderly people the general illness tends to be less severe or even entirely absent. Occasionally, this is true in patients of middle age.

At any age, rheumatoid arthritis, instead of involving many joints, may affect a single large joint, thus resembling early tuberculosis, from which it is indistinguishable without biopsy. However, other joints, especially small joints, may become affected years later.

LOCAL SIGNS

The signs in an affected joint are as follows.

LOOK — The skin appears shiny and atrophic. The joint is fusiformly swollen and the swelling, which extends beyond the confines of the synovial membrane, appears more obvious because of muscle wasting. Deformities produced by muscle spasm are a marked feature: ulnar deviation of the hands, and fixed flexion of the hips and knees, are common.

FEEL — During activity the skin feels moist and warm. There is diffuse tenderness but fluid is rarely detectable.

MOVE — During a phase of activity movement is restricted by pain and spasm. With quiescence a reasonably good range may return; but often considerable stiffness remains and occasionally fibrous ankylosis may occur.

X-RAY — After the early stages, the bones show marked widespread rarefaction, and there is a uniform decrease of joint space. Sclerosis is absent unless secondary degenerative changes (osteoarthritis) supervene.

DIFFERENTIAL DIAGNOSIS

Chronic arthritis affecting many small joints is almost always rheumatoid in nature. Occasionally, however, rheumatoid arthritis begins in one large joint, or perhaps two. The following conditions must then be considered.

TUBERCULOUS SYNOVITIS — The patient may present with a warm, swollen joint, muscle wasting, limited movement, a raised sedimentation rate and possibly rarefaction on

PHYSIOTHERAPY — Once the acute stage has subsided, movement is not only permitted, it is actively encouraged. The patient is helped to regain range of movement and muscle power by graduated active exercises, facilitated by warmth, soothing massage and wax baths. Intra-articular injections of hydrocortisone may be helpful.

OPERATIONS — When the disease is burnt out, operative procedures may be considered: (*a*) to correct deformity, for instance if there is fixed flexion at the knee the joint is straightened under anaesthesia and held in a straight plaster splint which is split to permit exercises; (*b*) to abolish pain, for instance if the knee has a small useless range of painful movement the fibrous ankylosis may be converted to a bony one by arthrodesis; or (*c*) to restore movement, for instance if both hips are stiff arthroplasty is occasionally worthwhile.

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Council

Clinical

They can have no effect upon deformities which are the legacy of old "burnt out" disease. Steroids must not be given to a patient with active tuberculosis, and are dangerous in patients with psychosis, peptic ulcer, diabetes, epilepsy or generalized osteoporosis.

Cortisone — This was the earliest of the steroids to be used and its effects are more fully known than those of the other steroids. The initial dose for an adult is usually 100 mg. per day (in 25 mg. tablets). If after 2 weeks there is no improvement the dose is temporarily increased, but if this fails, cortisone is abandoned. If the initial dose proves adequate it should, after 2 weeks, be gradually reduced until the minimum effective maintenance dose is reached. The aim is to ameliorate symptoms, not to suppress them completely, for this means that too much is being given. Any patient on steroid therapy should have a diet rich in protein and potassium, but poor in salt. And if he sustains a major injury, a temporarily raised dose of drugs is a wise measure.

Complications include mental changes (euphoria or depression and insomnia); changes in appearance (moonface, deposition of fat, hirsutism, acne and pigmentation); altered electrolyte balance (i[illegible] blood pressure; and [illegible] logical fractures may [illegible] healing is sometimes delayed. After prolonged therapy the adrenal cortex may become even "lazier" so that the patient is dependent upon the drug and suffers severely if it is withdrawn.

In view of this alarming list of side effects, and to help patients who do not respond to cortisone, other steroids which avoid some of the complications are being extensively tried. The following drugs are in current use.

Hydrocortisone — This is a natural hormone of the adrenal cortex which may be given by mouth (75 mg. per day initially) or by intravenous injection. Hydrocortisone acetate is [illegible]

[illegible] powerful, 25 mg. per day by mouth being a sufficient initial dose. They produce less retention of water and salt, but more liability to peptic ulceration.

ACTH (adrenocorticotrophic hormone) — This substance might be expected to stimulate natural adrenal secretion. In practice, it has few advantages over cortisone and the disadvantage that it has to be given intravenously, the initial daily dose being 25–40 units.

Other drugs — Intramuscular injections of gold have been used, and if given early are sometimes helpful, but dermatitis is a real danger. Chloroquine, an antimalarial drug, has recently been tried. Spa waters, sulphur, vaccines, bee venom and iodine lockets have all been used but are of no proved value.

NOTE — Of all the drugs, soluble aspirin remains the safest and, on the evidence of recent extensive controlled trials, as effective as any other drug, even the newer steroids.

LOCAL TREATMENT

SPLINTAGE — During the acute stage a joint may need splintage to relieve pain and prevent deformity. A widely split plaster is used, from which the limb is lifted every day and gently exercised. Although movement must never be forced the patient should make every effort to preserve it and the doctor should help by relieving pain. Nevertheless the joint may stiffen and splintage must therefore be in the optimum position (*see* pages 102–103).

PHYSIOTHERAPY — Once the acute stage has subsided, movement is not only permitted, it is actively encouraged. The patient is helped to regain range of movement and muscle power by graduated active exercises, facilitated by warmth, soothing massage and wax baths. Intra-articular injections of hydrocortisone may be helpful.

OPERATIONS — When the disease is burnt out, operative procedures may be considered: (*a*) to correct deformity, for instance if there is fixed flexion at the knee the joint is straightened under anaesthesia and held in a straight plaster splint which is split to permit exercises; (*b*) to abolish pain, for instance if the knee has a small useless range of painful movement the fibrous ankylosis may be converted to a bony one by arthrodesis; or (*c*) to restore movement, for instance if both hips are stiff arthroplasty is occasionally worthwhile.

Suggestions for further reading

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CHAPTER 4

TUBERCULOSIS

GENERALIZED TUBERCULOSIS

CAUSE

THE body is invaded by tubercle bacilli, human or bovine. Formerly, 85 per cent of cases were bovine in origin, but pasteurization and tuberculin-tested herds have reduced this figure to 25 per cent. The bacilli enter the body via the lung (droplet infection) or the gut (swallowing infected milk products) or, rarely, through the skin.

PATHOLOGY

PRIMARY COMPLEX — The initial lesion in lung, pharynx or gut is a small one with lymphatic spread to regional glands; this combination is the primary complex. Usually the bacilli are fixed in the glands and no clinical illness results, but occasionally the response is excessive, with clinical enlargement of glands in the neck or abdomen.

Even though there is usually no clinical illness, the initial infection has two important sequels: (*a*) within glands which are apparently healed or even calcified, bacilli may survive for many years, so that a reservoir for potential reinfection exists; (*b*) the body has been sensitized to the toxin (a positive Mantoux reaction being an index of sensitization), and should reinfection occur, the response is quite different, the lesion being a destructive one which spreads by contiguity.

SECONDARY SPREAD — If resistance to the original infection is low, widespread dissemination via the bloodstream may occur, giving rise to miliary tuberculosis or meningitis. More often blood spread occurs months or years later, perhaps because of lowered resistance. Bacilli escape from their lymphatic prison, and may be deposited in many tissues. Probably most of the bacilli are destroyed, but others survive giving rise to destructive lesions of which two or three often coexist.

TERTIARY LESION — The surgeon usually sees tuberculosis as a locally destructive lesion to which the term "tertiary" may be applied The bacilli, having gained a foothold in sensitized tissue, multiply. Giant-cell systems develop, grow and coalesce, destroying normal tissue and replacing it by caseous material. So long as this process is active, destruction and caseation continue to extend by direct contiguity.

CLINICAL FEATURES

Tuberculosis of bone or joint (or indeed any other part of the body) is merely the local manifestation of a general disease. In the section which follows, the symptoms

and signs of the general disease are considered. The patient may be ill early in the disease if the lymphatic barrier has failed; or later during the secondary spread; or while the tertiary lesion is actively extending (though frequently at this stage general illness is slight).

The symptoms are gradual in onset and the history is a long one, usually of several months. The patient may feel off colour and complain of lassitude, poor appetite, loss of weight and night sweats.

AGE — No age group is exempt. Children used to be the chief victims but the disease is now commoner in young adults.

GENERAL ILLNESS — The patient may be thin and pale, though sometimes there is a malar flush. Slight evening pyrexia is not uncommon; the sedimentation rate is raised and the Mantoux reaction positive.

LOCAL LESIONS — Although the patient presents with features of tuberculosis in only one part of his body, it is important to remember that two or three foci of disease often coexist. The common sites are the lung, the urogenital tract and a second focus in bone or joint.

TREATMENT

Prophylaxis is largely a public health problem. The essentials are uncrowded living conditions with an ample varied diet, clean milk, vaccination with B.C.G. vaccine, and the early diagnosis and isolation of patients with open tuberculosis.

General treatment of the established disease aims at improving the patient's well-being, increasing his resistance and destroying the bacilli. The essentials are recumbency, a sanatorium régime and drug therapy. Such treatment is necessary if a patient is ill and equally necessary if a joint is "ill" (even though local activity may not be accompanied by systemic illness). Moreover, general treatment must be continued until: (*a*) all evidence of general illness has subsided, that is, until the patient feels fit, has a good appetite, no pyrexia and a normal sedimentation rate; and (*b*) all evidence of local activity has subsided, until, for example, a joint is no longer painful, swollen or warm. Even after healing is apparently complete, regular observation over a long period is essential.

RECUMBENCY — The term "recumbency" is here preferred to "rest"; the upper limb, for example, may be rested without the patient being recumbent. It is of course important also to rest any local area of disease, not only because rest promotes local healing, but also to minimize fresh dissemination from that site.

Recumbency is necessary if the patient is ill. Prolonged recumbency, however, may lead to flabby muscles, which will later require physiotherapy, a flabby brain (hence the need for occupational therapy), and flabby or rarefied bones (the patient must therefore drink a lot or the calcium withdrawn from bone may be deposited as renal calculi).

SANATORIUM LIFE — A country hospital is not essential, nor does it cure tuberculosis. What is essential is to ensure good food, fresh air and freedom from work, want and worry. Few homes can provide such an ideal state, hence the value of sanatoria.

Moreover, tuberculosis takes a long time to heal. Formerly, the average stay in

hospital was 1 year for a tuberculous ankle, 2 years for a knee, 3 years for a hip and 5 years for a spine. Although antibiotics have enabled these times to be considerably reduced, the period in hospital is still a long one.

DRUGS — Drug therapy is indicated in the following circumstances.

(*a*) If the patient is ill in himself.

(*b*) If the disease is locally active. With early lesions, antibiotics may result in "cure" and even with later lesions the duration of activity is reduced, destruction minimized and sinuses may dry up.

(*c*) As an "umbrella". Formerly, operative procedures carried a serious risk of disseminating the disease, but with drug cover, biopsies, the evacuation of abscesses and the excision of diseased areas or dead bone are relatively safe. Moreover, by the removal of necrotic material the path may be cleared for an effective drug attack.

The drugs used are streptomycin, isoniazid and PAS. They must not be given singly or the bacilli will quickly develop resistance. Usually streptomycin is given with one or both of the other drugs. A course of drug treatment lasts at least 3 months, often 6 months, and occasionally longer. The doses stated below are for an adult of average weight; for children under 5 years the dose is halved

Streptomycin — 1 g. is given by intramuscular injection daily for 3 months, then every other day. Complications include vertigo, incoordination and deafness, but are very rare with the doses stated.

Isoniazid (iso-nicotinic acid hydrazide) — 200 mg. is given daily by mouth in 50 mg. tablets. The complications are essentially those of vitamin B deficiency; they are uncommon and can be prevented by giving the vitamin.

PAS (para-aminosalicylic acid) — 16 g. is given daily by mouth, as capsules or in solution. Complications include nausea and gastric upsets; they are largely prevented by modern preparations of the drug.

COMPLICATIONS

DISSEMINATION — The secondary spread of tuberculosis is via the bloodstream Consequently, miliary tuberculosis or meningitis may occur—both used to be fatal before the introduction of streptomycin—or a second focus of disease may be present; this is common, occurring in 30–50 per cent of cases, and makes the prognosis worse. The *chief sites of a second focus are the lung, the urogenital tract and the skeletal system.*

AMYLOID DISEASE — Amyloid substance is a degeneration product and the disease may follow chronic discharging wounds of bone or joint, whether tuberculous or septic. It also occurs in syphilis with chronic bone necrosis, in leprosy and in malaria. Insoluble protein from tissue destruction is deposited along the capillaries between the vessel walls and the tissue cells.

The patient is pale, puffy, waxy, wasted and oedematous. The spleen, kidney and liver are enlarged. Proof of diagnosis may be obtained by the congo red test, liver puncture, or gum biopsy. The only hope is total excision of the diseased area.

DEATH — Tuberculosis is still a killing disease. Toxaemia and septicaemia may overwhelm the patient early if no effective barrier to the original infection is produced, or much later, especially if multiple lesions are present.

JOINT TUBERCULOSIS

Joint tuberculosis is a local manifestation of a general disease. Nevertheless the disease as it affects any joint merits separate description and this is conveniently divided into four stages.

(1) *Early active disease (synovitis or osteomyelitis)* — The disease has the upper hand and the patient may be ill in himself. There is local active inflammation as shown by warmth, muscle wasting and bone rarefaction. The disease is early in that articular cartilage has not yet been attacked and restoration to normal is still possible.

(2) *Late active disease (arthritis)* — The disease is extending and the patient often is ill. Evidence of local active inflammation is more marked and muscle spasm usual. The disease is late in that articular cartilage has been damaged and restoration to normal is no longer possible.

(3) *Healing disease* — Gradually the patient gains the upper hand and masters the disease. Any general illness subsides. Locally the disease is arrested, pain and warmth disappear and the bones recalcify. If the disease was arrested before articular damage (early), healing may be by resolution to apparent normality; if articular cartilage has been damaged (late), healing is by fibrosis.

(4) *Aftermath* — Once a joint has suffered a true arthritis with erosion of articular cartilage the damage is permanent and the resulting fibrous joint is unsound. Increasing deformity may occur and even after many years of quiescence, bacilli may be liberated from their fibrous prison. The resulting flare may be only a local reactivation, or there may also be renewed bacillaemia and general illness.

STAGE 1: EARLY ACTIVE DISEASE

PATHOLOGY

Bacilli carried in the bloodstream are deposited in bone or synovium. A bone focus (osteomyelitis) consists of an irregular abscess cavity in the metaphysis or epiphysis; sometimes the cavity extends through the epiphyseal line. Synovial infection (synovitis) may be directly from the bloodstream or follow local extension from a bone focus. The synovial membrane becomes thick, grey and oedematous. As infection spreads in the subsynovial layer bone may be eroded at the synovial attachments. The joint is irritated by the adjacent focus but, in this early stage, articular cartilage is undamaged. Tuberculosis being a chronic inflammation, however, the blood supply is increased over a long period of time; this hyperaemia washes calcium out of the bones and, over a wide area, they become rarefied and soft.

SYMPTOMS

The cardinal symptoms of any joint disease are pain, limp, swelling, stiffness and deformity. All these may be minimal in early tuberculosis. Pain is usually slight or absent, sometimes no more than a little ache after activity. Limp is the usual presenting symptom in the lower limb; like pain it is at first slight and increased by activity. Swelling is noticed only in superficial joints like the knee, ankle, elbow and wrist; it is not gross but is easily noticed by the patient because of muscle wasting.

Stiffness and deformity, though present, are rarely complained of until articular cartilage has been attacked.

SIGNS

LOOK — The joint is held in a position of deformity and is a little swollen. Muscle wasting is marked and makes the joint swelling more apparent.

FEEL — The skin feels warm (not hot), and the joint contains some fluid (never a lot). It is sometimes possible to feel thickening of the synovial membrane and its attachments may be tender. A bone focus may also be slightly tender.

MOVE — Movement in all directions is limited, though at first by only a few degrees; attempting to force any movement to its extreme is painful and may provoke spasm. The muscles are wasted and the patient may be unable to make them properly taut.

X-RAY — Rarefaction is a constant and well-marked feature; the medulla looks like ground glass and the cortex like a thin line ("pencilling"). Sometimes the epiphyses are enlarged, probably (like the rarefaction) a result of long-continued hyperaemia.

With osteomyelitis, an irregular rarefied area is seen, often extending from metaphysis into epiphysis; with synovitis, bone may be eroded at the synovial attachments.

As long as the disease is in its early stages, the joint space remains normal in width and the joint line clean and unbroken. All these changes take time to develop and if the patient presents sufficiently early, the x-ray picture may be normal.

DIFFERENTIAL DIAGNOSIS

In the early stage tuberculosis may be difficult to diagnose with certainty. Nevertheless early and accurate diagnosis is essential, because tuberculosis can only be "cured" while still early.

TRANSIENT SYNOVITIS — Transient synovitis is the most important and most difficult condition from which tuberculosis must be differentiated. The cause is unknown. A joint becomes slightly painful and swollen, there is a little warmth and wasting, limitation of extremes of movement and a normal x-ray picture. In fact the joint is irritable just as in early tuberculosis, from which transient synovitis is clinically indistinguishable unless there is evidence of tuberculosis elsewhere.

Management — (1) The patient is put to bed for 3–6 weeks (if the hip is involved, skin traction is applied). During this time, other evidence of tuberculosis is sought by x-ray examination of the chest, Mantoux test, and so on. (2) If irritability has then disappeared, activity is gradually resumed under careful supervision (3) If irritability has persisted or returns with activity, biopsy of synovial membrane or of regional lymph nodes is performed. The specimen is sent for section, culture and guinea-pig inoculation. Drug treatment is started at once. (We used to wait and see if a joint was tuberculous, hence it was called an "observation" knee or hip; now we look and see.)

CHRONIC SYNOVITIS — Occasionally a chronic synovitis presents with warmth, wasting, irritability and generalized rarefaction It is clinically indistinguishable from tuberculosis but biopsy shows it to be rheumatoid in nature; and years later other joints may become involved. It is therefore a monarticular variety of what is usually a polyarthritis.

TRAUMATIC SYNOVITIS — Ligament injury may be followed by pain, swelling, slight warmth, loss of muscle tone and limited movement. But the history is of sudden onset after trauma, tenderness is localized, not all movements are restricted and the condition quickly subsides with rest.

OTHER CONDITIONS — At the hip and knee, certain special conditions need to be differentiated from tuberculosis. These are considered in the appropriate chapters.

TREATMENT

As long as a tuberculous joint remains active there are (in addition to general treatment) three principles governing local treatment:

REST — By this is meant local rest as distinct from recumbency. H. O. Thomas long ago said that the rest must be prolonged, uninterrupted, rigid and enforced. For the knee, his splint is still the best. A hip is most effectively rested on a double abduction frame, though for adults this is very cumbersome and often dispensed with. The shoulder may be rested in an abduction frame and the elbow in a plaster gutter, but for both these joints a simple sling is often used.

TRACTION — This overcomes spasm, prevents collapse of soft bone, and keeps inflamed surfaces apart. Skin traction is used for the knee, skin or skeletal traction for the hip, and gravity plus a sling for the upper limbs.

"DRAINAGE" — A tuberculous osteomyelitis in an accessible site should be evacuated and the wound sutured; this may prevent it from bursting into the joint.

COMPLICATIONS

The local complications of tuberculous arthritis may be an abscess, a sinus or occasionally cellulitis.

ABSCESS — An abscess forms when the bone or joint is perforated. Caseous material, often in large quantities, exudes along the soft-tissue planes. The abscess walls are thick and its contents creamy. A fluctuant swelling forms which, unlike a pyogenic abscess, is not hot (hence the term "cold abscess"). Abscesses are common in deep-seated tuberculosis, but less so at superficial joints because pus can easily burst through the skin.

The usual treatment of an abscess is aspiration, repeated when necessary. After a while the contents become too thick to flow through a needle and it is then best, under antibiotic cover, to incise the abscess, evacuate its contents and suture the skin. In some centres this is replacing aspiration as the treatment of all cold abscesses.

SINUS — When an abscess becomes subcutaneous it is liable to perforate the skin and give rise to a sinus; often this is an index of poor resistance. The sinus track communicates with the joint and so may permit secondary infection.

In treatment, streptomycin instilled into the sinus is often successful Given in this way, the drug is still absorbed, so care must be taken to avoid the total dosage being excessive

CELLULITIS — Occasionally, if the patient's resistance is poor, the body fails to make a fibrous barrier, and bacilli invade the surrounding tissues. The limb looks red and

Stiffness and deformity, though present, are rarely complained of until articular cartilage has been attacked.

SIGNS

LOOK — The joint is held in a position of deformity and is a little swollen. Muscle wasting is marked and makes the joint swelling more apparent.

FEEL — The skin feels warm (not hot), and the joint contains some fluid (never a lot). It is sometimes possible to feel thickening of the synovial membrane and its attachments may be tender. A bone focus may also be slightly tender.

MOVE — Movement in all directions is limited, though at first by only a few degrees; attempting to force any movement to its extreme is painful and may provoke spasm. The muscles are wasted and the patient may be unable to make them properly taut.

X-RAY — Rarefaction is a constant and well-marked feature; the medulla looks like ground glass and the cortex like a thin line ("pencilling"). Sometimes the epiphyses are enlarged, probably (like the rarefaction) a result of long-continued hyperaemia.

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As long as the disease is in its early stages, the joint space remains normal in width and the joint line clean and unbroken. All these changes take time to develop and if the patient presents sufficiently early, the x-ray picture may be normal.

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condition. Onset is rapid and the patient ill with a high swinging fever. There is leucocytosis and a positive blood culture.

SUBACUTE ARTHRITIS — Occasionally diseases such as amoebic dysentery or smallpox are complicated by arthritis. *The history usually enables a diagnosis to be made, and* the x-ray picture differs from [illegible]

HAEMOPHILIC ARTHRITIS — Af [illegible] nd x-ray picture resemble *those* [illegible]

TREATMENT

General treatment (recumbency, sanatorium régime and drugs) is of course essential. Local treatment is the same as in the early active stage and has already been discussed under the headings of rest, traction and "drainage". The joint must certainly be rested, and traction is necessary to overcome spasm and deformity. An abscess may require evacuation, and a few surgeons advise excising diseased synovial membrane and clearing out tuberculous débris and sequestra; they claim that healing is quicker, which is probably true. It is also claimed, however, that *radical surgery may result in a useful range of movement being retained.* Most surgeons consider it unwise ever to encourage movement after a true tuberculous arthritis. The safe maxim is: after arthritis aim at stiffness.

STAGE 3: HEALING

PATHOLOGY

If the disease is arrested before articular cartilage has been damaged, healing by resolution may occur. Once there has been a true arthritis, however, although healing may occur, restoration to normal is impossible. Tuberculous granulation tissue is slowly converted to fibrous tissue in which the bacilli are imprisoned. Opposing joint surfaces stick together giving a fibrous ankylosis which may be long (as in the hip or elbow) or short (as in the knee). Bony ankylosis almost never *occurs unless there has been secondary infection.*

SYMPTOMS

The patient feels fit and the joint is no longer painful. Because he is at this stage usually in bed undergoing treatment other symptoms are not relevant.

SIGNS

The local signs may be summed up by saying that the patient is fit and the joint as fit as possible.

LOOK — The joint is not swollen, though some wasting is still present. Any sinus will have dried up.

FEEL — The skin is no longer warm, and the joint no longer thick or tender.

MOVE — If early disease has healed by resolution movement slowly returns; if there has *been articular destruction,* stiffness remains.

swollen and feels hard and board-like. Formerly amputation was sometimes necessary, but with streptomycin and adequate general and local treatment cellulitis usually subsides.

STAGE 2: LATE ACTIVE DISEASE

PATHOLOGY

A tuberculous focus in bone or synovium irritates the joint. Either focus, however, may extend or erupt into the interior of the joint. Once penetration has occurred, spread throughout the joint is rapid. A pannus of tuberculous granulation tissue spreads over the synovial membrane and across the articular cartilage. Infection also extends in the subchondral bone, so that the articular cartilage is attacked on both sides. It is extensively eroded, but not completely absorbed, for this requires phagocytes as in a septic arthritis.

The term "tuberculous arthritis" is best reserved for the condition just described, in which articular destruction has taken place. If unchecked, the tuberculous caseation extends into the soft tissues as an abscess; this in turn may track to the surface forming a sinus.

SYMPTOMS

The cardinal symptoms of joint disease (pain, limp, swelling, stiffness and deformity) are all present and are much more severe than in the early stage. Pain is sometimes constant, or may take the form of "night cries", the explanation of which is that during waking hours the joint is held immobile by muscle spasm and as this relaxes with sleep the damaged joint surfaces rub together, waking the patient. If the patient is able to walk a pronounced limp is present. Swelling and wasting are marked, stiffness considerable and deformity (especially shortening) usually obvious.

SIGNS

LOOK — The joint is held in a position of deformity, it is swollen and the muscles are grossly wasted. An abscess or sinus may be visible.

FEEL — The skin is warm and the joint feels thick, doughy and diffusely tender; these signs can be elicited only in superficial joints.

MOVE — All movements are grossly limited and may be virtually abolished. Attempted movement is painful and provokes muscle spasm

X-RAY — Rarefaction with "pencilling" is marked. The joint space is abnormal, being narrowed if the destruction is mainly of cartilage, or widened if much bone has been eroded; the joint line is irregular.

DIFFERENTIAL DIAGNOSIS

Usually, in the late active stage, diagnosis is easy. The following conditions are the only ones at all likely to present difficulty.

ACUTE ARTHRITIS — An arthritis due to pyogenic organisms is usually a dramatic

condition. Onset is rapid and the patient ill with a high swinging fever. There is leucocytosis and a positive blood culture.

SUBACUTE ARTHRITIS — *Occasionally diseases such as amoebic dysentery or smallpox* are complicated by arthritis. The history usually enables a diagnosis to be made, and the x-ray [illegible]

HAEMOPHIL[illegible] nd x-ray picture resemble those of tuberculosis; there is a history of bleeding elsewhere.

TREATMENT

General treatment (recumbency, sanatorium régime and drugs) is of course essential. Local treatment is the same as in the early active stage and has already been discussed under the headings of rest, traction and "drainage". The joint *must certainly be rested, and traction is necessary* to overcome spasm and deformity. An abscess may require evacuation, and a few surgeons advise excising diseased synovial membrane and clearing out tuberculous débris and sequestra; they claim that healing is quicker, which is probably true. It is also claimed, however, that radical surgery may result in a useful range of movement being retained. Most surgeons consider it unwise ever to encourage movement after a true tuberculous arthritis. The safe maxim is: after arthritis aim at stiffness.

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If the disease is arrested before articular cartilage has been damaged, healing by resolution may occur. Once there has been a true arthritis, however, although healing may occur, restoration to normal is impossible. Tuberculous granulation tissue is slowly converted to fibrous tissue in which the bacilli are imprisoned. Opposing joint surfaces stick together giving a fibrous ankylosis which may be long (as in the hip or elbow) or short (as in the knee). Bony ankylosis almost never occurs unless there has been secondary infection.

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The patient feels fit and the joint is no longer painful. Because he is at this stage usually in bed undergoing treatment other symptoms are not relevant.

SIGNS

The local signs may be summed up by saying that *the patient is fit* and *the joint as fit as possible.*

LOOK — The joint is not swollen, though some wasting is still present. Any sinus will have dried up.

FEEL — The skin is no longer warm, and the joint no longer thick or tender.

MOVE — If early disease has healed by resolution movement slowly returns; if there has been articular destruction, stiffness remains.

X-RAY — The bones recalcify, and a synovitis may gradually return to normal. Osteomyelitis, even though it heals, leaves some permanent alteration of bone architecture. An arthritis, even though recalcified, has a permanently altered joint space and an irregular joint line.

NOTE — At superficial joints like the knee, the healing stage is easy to recognize by feeling the joint; hence the value of a Thomas' splint rather than plaster. In deeper joints, like the hip or shoulder, healing is recognized by the condition of the patient and by the x-ray picture.

TREATMENT

As the disease heals, general treatment is gradually discontinued. Local treatment depends upon whether the disease was arrested early or only arrested after it had progressed to a true arthritis.

IF ARRESTED EARLY — The aim is to restore movement, therefore splints are removed. *The joint is, however, protected from stress, which is only gradually allowed.*

Thus in the lower limb, the patient first lies in bed without splints but still on traction. The traction is then released for increasing periods and finally removed altogether so that the patient kicks freely in bed. He then gets up but avoids taking weight (using a patten and crutches for the hip and a weight-relieving caliper for the knee). After a time he is allowed to take weight for gradually increasing periods until he is walking about normally.

During all this time he is continually observed. If symptoms or signs increase, he goes back a stage; if there is steady progress he goes forward (Thomas' test of recovery). At no time is movement forced; it is only permitted to return of its own accord.

In the upper limb treatment is much simpler, for the splint or sling is merely dispensed with for increasing periods of time while the patient uses his arm.

IF ARRESTED LATE — The aim, once articular cartilage has been destroyed, is to obtain the shortest possible fibrous ankylosis in the optimum position. Movement must therefore be prevented but stress is permitted so that the joint surfaces impinge more closely together.

In the lower limb traction is taken off and a caliper or plaster applied with the joint in the optimum position Weight bearing is started. After some months a removable splint (of polythene, leather or metal) may be used and is taken off for bath or bed. Some form of splint will usually be needed permanently or until the joint is arthrodesed. (A few surgeons treat a mild arthritis in the same way as early disease, hoping to regain a fair range of movement, and sometimes succeeding. This is not very safe, nor is it known how long such success may last.)

In the upper limb a somewhat longer fibrous ankylosis may be permitted and indeed is almost inevitable, because gravity exerts a constant traction force. At the shoulder, even after arthritis, splintage is gradually discarded; a sling is used for a time and gradually left off. If there is pain the joint is arthrodesed. At the elbow, a moulded leather or polythene splint may be used permanently, but often a sling is sufficient and sometimes even this may be dispensed with.

STAGE 4: AFTERMATH

PATHOLOGY

A joint which has suffered a true arthritis heals by fibrosis (unless there has been secondary infection). A fibrous joint is "unsound" because (*a*) the fibrous tissue shrinks with time, giving increasing deformity; and (*b*) it may tear with stress, liberating bacilli and provoking a flare.

SYMPTOMS

There is stiffness and, in the lower limb, a limp. Pain may be felt at times, especially after the joint has been subjected to stress. Deformity is usually present and may slowly increase with time; after hip disease, for example, the leg may appear to get shorter as adduction deformity increases.

SIGNS

LOOK — Scars from old sinuses are common. The limb may be held in a deformed position, it may be short and is always thin.

Deformity is due, not only to bone destruction, but also to prolonged muscle spasm and therefore the stronger muscles tend to pull the joint into characteristic positions (for example, flexion, adduction and internal rotation at the hip; flexion, backward subluxation and external rotation at the knee).

FEEL — There is no warmth or tenderness unless there has been a recent flare.

MOVE — Movement is always considerably limited. At the knee a short fibrous ankylosis often occurs so that only a few degrees of movement are present. Elsewhere there may be up to half the normal range.

X-RAY — The bone is well calcified but its architecture is often faulty. The joint space may scarcely be visible and the joint line is grossly irregular. Abscesses in the vicinity of the joint may be calcified.

DIFFERENTIAL DIAGNOSIS

The aftermath of an old tuberculous joint is usually easy to diagnose. There are, however, three other fairly common causes of a stiff, deformed or painful joint of long standing.

OLD SUPPURATIVE ARTHRITIS — The history is of a more acute illness and there is often bony ankylosis.

RHEUMATOID ARTHRITIS — Many joints are affected, commonly small joints, particularly in the hands.

OSTEOARTHRITIS — There are no scars, little wasting and x-rays show diminution of joint space only at the stress area, with underlying sclerosis; there may be lipping and osteophytes.

TREATMENT

In the absence of a flare no general treatment is required.

LOCAL TREATMENT —

Conservative — The only treatment required may be a removable splint, and in the lower limb, a raised shoe.

Operative — For deformity, especially at the hip, an osteotomy is valuable.

For unsoundness at any joint arthrodesis is the best treatment. An extra-articular arthrodesis is possible at the hip or shoulder, but elsewhere it must be intra-articular. At the knee or ankle Charnley's compression technique is often used.

For deformity plus unsoundness, the joint is arthrodesed and deformity corrected at the same time. At the hip it is convenient to combine extra-articular arthrodesis by means of an ischio-femoral graft with an osteotomy (Brittain's operation).

COMPLICATIONS

The most important complication of an old tuberculous arthritis is a flare. This is a local reactivation of the disease, though it may be accompanied by a lighting-up of the general illness too. A flare may occur if the patient's resistance drops, or if trauma liberates bacilli from their fibrous prison. That is why a fibrous joint is an unsafe joint.

If an old tuberculous joint suffers trauma it is probably wise not to await a flare, but to put the joint at rest immediately and to institute drug treatment. If a flare has actually occurred these measures are certainly necessary and it is best, once active inflammation subsides, to proceed with arthrodesis.

EXTRA-ARTICULAR TUBERCULOSIS

Tuberculosis of bone or synovium may, as already described, irritate a joint, or erupt into and infect it. Tuberculosis may also, however, involve bone without affecting a joint and may attack the synovial lining of tendon sheaths or bursae.

TUBERCULOUS OSTEOMYELITIS

Within the bone an irregular area of destruction occurs and may be seen on x-ray. The infection being chronic is often not painful and may remain clinically silent until one of the following occurs.

SOFT BONE COLLAPSES — This occurs particularly in the spine where a diseased vertebral body collapses, infecting the one below and squashing caseous material into the soft tissues as an abscess (*see* Spinal Tuberculosis, page 164).

A SWELLING APPEARS — In tuberculosis of flat bones (rib or skull) an abscess is the usual presenting feature; in tuberculous dactylitis a localized swelling or a sinus is usual (*see* page 143).

SYNOVIAL TUBERCULOSIS

Infected synovium becomes thick, oedematous and villous. Excess fluid may be produced, giving a painless swelling and, where there is friction, particles of fibrin

are moulded to resemble melon seeds. Synovial infection may affect tendon sheaths or bursae.

TENOSYNOVITIS — The commonest site for tenosynovitis is in front of the wrist (*see* Compound Palmar Ganglion, page 138), but the fingers or ankle region are sometimes affected. A painless swelling appears insidiously; it is fluctuant and often there is weakness and muscle wasting. Instillation of streptomycin is sometimes successful, or excision of the sheath may be necessary.

BURSITIS — The least rare sites for bursitis are the subdeltoid and gluteal bursae. A painless, cold, fluctuant swelling slowly develops, wasting is slight and the underlying joint normal. Treatment is by excision under drug cover.

Suggestions for further reading

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CHAPTER 5

OSTEOARTHRITIS AND OSTEOCHONDRITIS

I: OSTEOARTHRITIS

ESSENTIALLY, osteoarthritis is not an inflammation but a degeneration, a premature old age of the joint and especially of the articular cartilage. The initials "OA" conveniently stand for old age or osteoarthritis.

GENERAL CAUSES

Osteoarthritis is a local disease and general causes are of little importance. It is traditional to include old age of the patient, and obesity (which aggravates rather than causes osteoarthritis).

LOCAL CAUSES

INJURY — Articular cartilage may be damaged by a single major injury, or be repeatedly damaged by recurrent subluxation (for instance, of the patella) or by a loose body. Osteochondritis dissecans is a potent cause of osteoarthritis because not only may the separated fragment inflict repeated trauma on cartilage, but the crater which it leaves also results in incongruity of opposing joint surfaces. Repeated bleeding, as in haemophilia, and continual unrecognized injury, as in Charcot's disease, are rare causes of articular cartilage damage.

INCONGRUITY — Articular cartilage degenerates if, as a result of deformity, the direction of stress transmission is abnormal Thus, at the hip it may follow subluxation or a slipped epiphysis, and at the knee, genu varum.

INADEQUATE BLOOD SUPPLY — In pseudocoxalgia the femoral head loses its blood supply and flattens. Incongruity results, with articular degeneration. Osteochondritis dissecans (referred to under Injury above) may be a localized form of avascular necrosis.

INFECTION — In itself infection does not cause osteoarthritis, but a disease such as rheumatoid arthritis damages articular cartilage and degenerative changes are then likely to supervene.

IDIOPATHIC — In most cases of osteoarthritis, no cause is discovered.

PATHOLOGY

The changes in the various tissues are considered separately.

ARTICULAR CARTILAGE — Some areas of cartilage normally transmit pressure, others do not. Both areas degenerate but the effects in each are different.

In the pressure area, degenerate cartilage is worn away (so that on x-ray the joint space decreases). The cartilage loses its smooth, shiny appearance, becoming fibrillated, rough and opaque. Fragments of cartilage (detritus) flake off.

In the non-pressure area degenerate cartilage is not rubbed away but becomes heaped up. Recent work by Trueta suggests that the articular cartilage degeneration starts (rather surprisingly) in the non-pressure area, beneath which increased vascularity occurs. Blood vessels then grow in under the pressure area whose cartilage, in its turn, degenerates; because there is pressure, bone collapse then follows.

BONE — Where cartilage has worn away, the underlying bone becomes hard and sclerosed. It has a polished (eburnated) look. At some joints, notably the hip, cysts develop, possibly because surface cracks allow synovial fluid to be pumped into the bone.

Where cartilage has become heaped up, it may calcify and ossify, causing lipping and osteophytes.

CAPSULE — The capsule becomes thick and fibrosed. (A possible explanation for the fibrosis is as follows. Detritus from cartilaginous wear is deposited on and sinks into synovial membrane; if the detritus particles are small, they are phagocytosed, but large particles migrate to the subsynovial layer and capsule, and there act as foreign-body irritants.) As the fibrous tissue matures, it shrinks, thus limiting extremes of movement.

At some joints, such as the hip and knee, extremes of range are required for ordinary use, therefore even slight capsule shrinkage produces symptoms. In addition, the patient unconsciously tries to force the joint to its extremes but (because fibrous tissue cannot stretch) minute tears occur, and heal with more fibrosis and further shrinkage. At these "extreme-range" joints the disease is noticed early and progresses quickly.

Other joints, such as the shoulder and elbow, rarely need extremes of range, so that slight capsule shrinkage produces no symptoms. Because the patient does not need to force the joint to its extremes, the disease progresses very slowly. At such "middle-range" joints osteoarthritis is rarely a problem.

JOINTS AFFECTED — It is usually stated that osteoarthritis chiefly affects weight-bearing joints. However, a joint such as the ankle is weight bearing, but rarely needs extremes and rarely suffers from osteoarthritis, whereas the carpometacarpal joint of the thumb is [illegible]

OTHER TISSUES — Synovial membrane may proliferate, sometimes producing excessive fluid which is abnormally alkaline. A pouch of synovium filled with fluid may herniate through the capsule and become sealed off to form a cyst (Baker's cyst).

Muscles often waste slightly because of disuse.

GENERAL SYMPTOMS

There are no general symptoms.

LOCAL SYMPTOMS

PAIN — This is the leading symptom. In early osteoarthritis pain occurs after a night's rest and then wears off; later, after use, the joint aches again. As the disease progresses, pain becomes more severe and more constant, sometimes disturbing sleep.

STIFFNESS — This too is an important symptom. At first it is noticed only after the joint has been still for some time. Later it is constant and gradually increases.

DEFORMITY — Capsule shrinkage produces deformity. At the hip the patient may notice increasing shortness of the leg because of flexion and adduction deformity.

LIMP — This is common and due to pain or deformity.

GIVING WAY — This sometimes occurs, possibly because a synovial fringe has been nipped, or occasionally because an osteophyte has broken off to form a loose body.

SWELLING — Swelling is only noticeable at superficial joints such as the knee.

GENERAL SIGNS

The patient is fit and, unless there has been some definite predisposing cause, is aged over 50 years when first seen. One joint only is affected; occasionally two or even three may be involved, but this is not a true polyarticular disease like rheumatoid arthritis.

LOCAL SIGNS

LOOK — There are no scars and only slight wasting. Swelling may be due to fluid (in the knee) or to osteophytes (at the metatarsophalangeal joint of the hallux). Deformity may be obvious—the hip may be held flexed, adducted and externally rotated.

FEEL — There is no warmth and only occasionally tenderness. In superficial joints fluid or osteophytes may be felt.

MOVE — Movement is always restricted, but is painless within the permitted range. The restriction of movement is characteristically asymmetrical; some movements are much more limited than others. Thus, at the hip, extension, abduction and internal rotation are far more limited than their opposites; and at the hallux, dorsiflexion is lost while plantarflexion may remain. This "asymmetry" probably occurs because the loss of movement is capsular in origin and not due to prolonged muscle spasm as in a true arthritis.

X-RAY — The joint space is diminished but only at the pressure area (unlike infective arthritis where the reduction is uniform), beneath this area there is sclerosis and, at the hip, cysts sometimes occur. At the non-pressure areas there may be lipping and osteophytes. *The severity of the symptoms bears no relation to the extent of the x-ray changes.*

TREATMENT IN PRINCIPLE

There are three main principles of treatment.

(1) DEAL DIRECTLY WITH PAIN — (disregarding its cause).

Analgesics — Aspirin and codeine are invaluable; phenylbutazone occasionally helps where these have failed

Warmth — A hot-water bottle, flannel bandage, liniments, massage and radiant heat are all methods of applying superficial warmth. Short-wave diathermy penetrates more deeply and so does radiotherapy, though why the latter occasionally helps is not known.

Anaesthetics — Local anaesthetics may be injected into the joint, sometimes in combination with hydrocortisone acetate. Partial denervation by neurectomy has been used at the hip.

(2) DEAL WITH THE CAPSULE — (where the pain chiefly originates). The capsule may be either relaxed, rested, removed or stretched.

Relaxed — The capsule may be relaxed at the metatarsophalangeal joint of the hallux by a rockered sole or by excising the metatarsal head; at the knee or hip by means of a raised heel or a walking stick which allows the patient to walk without forcing the joint straight.

Rested — It may be rested temporarily by a splint or permanently by arthrodesis.

Removed — Capsulectomy is an important stage in hip arthroplasty.

Stretched — In early cases it may be worthwhile to try to stretch the capsule by manipulation under anaesthesia, and to inject hydrocortisone to discourage subsequent fibrosis.

(3) DIMINISH THE LOAD — The stress passing through a joint can be reduced in various ways.

Diet — Loss of weight is especially useful in osteoarthritis of the hip, and to some extent in osteoarthritis of the knee.

Reduce activity — The patient should regulate his life so that he may ride rather than walk and sit rather than stand. Non-weight bearing exercises are, however, encouraged within the limits of pain.

Redistribute stress — A walking stick effects tremendous reduction in the stress passing through the hip, and an osteotomy, by correcting deformity, also places the hip in a position of much greater mechanical advantage.

TREATMENT IN PRACTICE

To choose from the above list of possible methods, the main question to ask is: how bad is the pain?

If pain is mild, treatment is medical (conservative). Possible measures include regulation of the patient's life and of his diet, analgesics, warmth, liniment, massage, short-wave diathermy and, rarely, high-voltage x-ray therapy. Manipulations under anaesthesia and injections of local anaesthetic with hydrocortisone sometimes help in early cases. In addition, shoe alterations, removable splints and a walking stick may be required.

If pain is severe, treatment is surgical. The operations most used are arthrodesis (for pain), arthroplasty (for pain and stiffness) and osteotomy (for pain and deformity).

REGIONAL SURVEY OF OSTEOARTHRITIC JOINTS

Acromioclavicular joint — [illegible] is pain, tenderness and lim[illegible] conservative; only very ra[illegible] the lateral end of the clavicle excised.

Glenohumeral joint (*see* page 123) — Osteoarthritis of the shoulder is much rarer than is commonly supposed, but cuff lesions are often diagnosed incorrectly as osteoarthritis.

Elbow (*see* page 131) — Osteoarthritis may follow severe injuries or loose bodies. Although

limitation of movement occurs early the patient rarely complains of it. Later, stiffness increases and there may be pain. Still later, ulnar palsy may present with numbness and weakness of the hand. For pain, the treatment is physiotherapy and a hinged removable splint. Operation, other than for removal of loose bodies, is rarely needed, but arthroplasty (for bilateral disease) and arthrodesis have been used. The ulnar nerve may need to be transplanted or the ulnar tunnel slit.

Wrist (*see* page 136) — Osteoarthritis of the radiocarpal joint usually follows injury. A polythene splint with the wrist slightly dorsiflexed is usually sufficient treatment. Where osteoarthritis is associated with non-union of the scaphoid bone and avascular necrosis, excision of the radial styloid process is useful. Only rarely is arthrodesis necessary.

Thumb (*see* page 137) — The carpometacarpal joint is a common site for osteoarthritis, but surgery is not often necessary. Arthrodesis gives excellent results but the wrist must be kept in plaster for 3 months after operation. Arthroplasty (excision of the trapezium) allows the patient to return to work in 2–4 weeks and also gives very good results, but complete relief from pain is less certain than with arthrodesis.

Cervical spine (*see* page 157) — Osteoarthritis of the intervertebral joints usually accompanies disc degeneration and the disease is then called spondylosis. Neck movements are limited and pain radiates from the neck to one or both upper limbs. Physiotherapy, a collar, or occasionally manipulation (without anaesthetic) are useful.

Lumbar spine (*see* page 182) — Osteoarthritis of the intervertebral joints may follow spinal deformities, or be associated with degeneration of discs (spondylosis). Physiotherapy and a corset are the usual methods of treatment, rarely spinal fusion is used.

Hip (*see* page 203) — Osteoarthritis of the hip is a common and important clinical problem. There is pain, often referred to the knee, stiffness and deformity. In conservative treatment a raised heel and a walking stick are especially useful. Arthrodesis may be needed for pain; or osteotomy for pain and deformity; or arthroplasty, where the lumbar spine, the knee or the other hip are stiff.

Knee (*see* page 227) — Osteoarthritis affects the patello-femoral section of the knee much more often than the femoro-tibial. At the patello-femoral section, it is often a sequel to chondromalacia patellae; if conservative measures (physiotherapy, a removable splint, manipulation and injections) fail, the patella may be excised, usually with a good result.

Osteoarthritis of the femoro-tibial section may rarely require arthrodesis. Arthroplasty has been tried but without success

Ankle (*see* page 235) — Although the ankle is a weight-bearing joint, extremes of movement are rarely required and osteoarthritis is therefore uncommon. It may follow severe injury or a loose body. If conservative measures fail, arthrodesis is the best operation.

Hallux (*see* page 246) — Osteoarthritis of the metatarsophalangeal joint (hallux rigidus) is common. A rockered sole usually relieves the pain. The commonest operation is arthroplasty in which the metatarsal head or the proximal portion of the phalanx is excised The joint is rarely arthrodesed.

II: NEUROPATHIC JOINTS (CHARCOT'S DISEASE)

CAUSE AND PATHOLOGY

A neuropathic joint is one in which the appreciation of pain and position sense from the capsule is lost. Consequently there is no reflex safeguard against injuries and a rapid progressive degeneration occurs.

The underlying neurological condition is usually tabes, occasionally syringomyelia,

rarely peripheral nerve injury. Tabes usually affects lower-limb joints and the spine, syringomyelia the shoulder and elbow.

GENERAL SYMPTOMS AND SIGNS

In tabes, adults over 45 years are usually affected. They often complain of lightning pains. The pupils may be Argyll Robertson in type; knee and ankle jerks are often lost, and there is no pain on squeezing the tendo achillis.

In syringomyelia the condition often dates from early adult life. Characteristically, there is dissociated sensation (loss of pain and temperature sense, but not of touch). Scoliosis is common.

LOCAL SYMPTOMS AND SIGNS

The patient complains of weakness, instability, swelling and deformity of the affected joint. The symptoms may progress surprisingly rapidly. The appearance of an established Charcot's joint suggests that movement would be agonizing, and yet it is painless. This paradox is diagnostic. A useful maxim is: "If it's bizarre, do a W.R."

LOOK — Swelling is considerable and deformity gross. The joint may be subluxed or even dislocated.

FEEL — There is no warmth or tenderness. Fluid is greatly increased and bits of bone can be felt everywhere.

MOVE — Often the joint is flail, normal movements being increased and abnormal movements present. These movements are painless.

X-RAY — The joint is subluxed or dislocated, gross bone erosion is obvious and there are irregular calcified masses in the capsule.

TREATMENT

The underlying condition may need treatment, but the affected joints *cannot* recover. They should, if possible, be stabilized by external splintage (for instance, by a caliper). Operation is not advised.

III: OSTEOCHONDRITIS

This is a collection of entities which fall into three distinct and quite different groups.

"CRUSHING" OSTEOCHONDRITIS

CAUSE

The blood supply to an ossific centre is cut off (avascular necrosis). Why this should be restricted to certain sites and *particular ages* is unknown. Theories include the following:

TRAUMA — This is the likeliest explanation as there is often a history of gradual strain or definite injury. But in many cases a history of injury is lacking.

DYSPLASIA — Minor developmental errors may, by subjecting the capsule to undue strain, predispose to blood-vessel injury.

INFECTION — This has been put forward as a possible explanation in pseudocoxalgia, because a few patients are pyrexial, and staphylococci have on occasion been cultured; but most patients have no fever and the pathology is unlike that of an infection.

OTHER THEORIES — Constitutional, metabolic or endocrine disorders (which are unlikely because the disease is a local one) have been incriminated; and aseptic emboli, which possibly do occur but for which no evidence is available, have also been suggested.

PATHOLOGY

The pathological description of "crushing" osteochondritis is based on a study of serial x-rays.

NECROSIS — Avascular bone dies and therefore appears more dense on x-ray (dead bone is dense bone). Moreover, dead bone does not grow, so that the joint space may appear to increase; and dead bone crumbles easily, causing fragmentation and flattening.

REPLACEMENT — Dead bone is replaced by a process known as "creeping substitution". New blood vessels grow in and, as dead bone is removed piecemeal, patchy rarefaction is seen; the soft rarefied bone may, with pressure, flatten further. Eventually, the dead bone is entirely replaced by bone of normal density and architecture; the new bone, however, being laid down in a distorted framework, is permanently faulty in shape and early osteoarthritis is a likely sequel.

REGIONAL SURVEY OF "CRUSHING" OSTEOCHONDRITIS

The first two varieties described affect the end of a bone, the next two the whole of a bone, and the last two affect the spine.

Hip (Perthes' disease) — The changes occur in children aged 5–10 years. The hip joint is temporarily irritable, with slight ache and limp. Later there are few signs except perhaps loss of abduction in flexion X-rays show the femoral head flat, dense and fragmented, and the joint space increased The gross x-ray changes are in marked contrast with the paucity of clinical signs. Weight bearing should be prevented until the head has re-formed.

Metatarsal (Freiberg's disease) — The patient presents between the ages of 15 and 25 years with metatarsalgia. The second metatarsal head feels thick and tender, and the neighbouring joint is irritable X-rays show a flat metatarsal head, thick neck and increased joint space. If a protective pad fails to give relief, the metatarsal head is excised.

Tarsal scaphoid (Kohler's disease) — A child aged between 3 and 5 years presents with pain, limp, local swelling and tenderness. The bony nucleus is squashed, fragmented and dense. Complete recovery occurs if the foot is temporarily rested.

Carpal semilunar (Kienbock's disease) — This presents in young adults. Long after trivial or repeated injury the wrist becomes painful, stiffish and locally tender. The semilunar bone looks squashed, dense and fragmented. Later, osteoarthritis develops. Splintage often helps but arthrodesis may prove necessary.

Vertebral epiphyses — In the thoracic spine (Scheuermann's disease), the plate-like upper and lower epiphyses of several adjacent vertebrae (usually thoracic 6–10) appear fragmented, the bodies become wedge-shaped, and the disc spaces narrow. Adolescents present with a

smooth rigid kyphosis and pain. Treatment consists of rest for a few months followed by the wearing of a brace. Pain in the lumbar spine may be a late sequel.

In the lumbar spine, only the front of the plate-like epiphysis is affected, and usually only one or two vertebrae. The front corner of a vertebra looks eroded, the disc space below narrowed, and the body below expanded. Adolescents complain of pain and stiffness after exercise. Once tuberculosis has been excluded, no treatment is necessary and spontaneous recovery occurs.

One vertebral body (*Calvé's disease*) — In this rare condition the bony nucleus of a single body is affected. The body becomes grossly flattened, but the disc spaces remain normal. A child aged under 10 years develops back pain and an angular kyphos. Recovery occurs after a few months' rest, though the vertebra never regains its full height.

"SPLITTING" OSTEOCHONDRITIS (DISSECANS)

CAUSE

The cause of "splitting" osteochondritis is unknown. Theories include the following:

TRAUMA — Only convex surfaces are affected by trauma, and it is suggested that impact of the opposed bony surfaces causes local damage.

VASCULAR — It is possible that thrombosis or embolism of an end artery leads to death of a piece of bone and cartilage.

CONSTITUTIONAL — In a few instances several joints are affected in several members of a family.

PATHOLOGY

An ovoid piece of bone ½–1 inch in diameter and less in height becomes separated, presumably because it is dead. First, a line of demarcation appears which becomes more obvious until on x-ray it looks as if the segment is lying in a cavity. At this stage revascularization with return to normal can still occur.

Later, the segment become spartly detached and flaps into the joint, finally breaking off to form a loose body. Osteoarthritis is a likely sequel.

REGIONAL SURVEY OF "SPLITTING" OSTEOCHONDRITIS

The knee is much the commonest joint to be affected, then the elbow, and rarely the ankle. In all, the condition probably starts in late adolescence but may not present until a loose body causes locking or osteoarthritis develops.

Knee (*femoral condyle, see* page 226) — The patient may present aged 15–20 years with vague ache or swelling and a tender medial femoral condyle (rarely lateral). At this stage x-rays show *a line of demarcation and recovery may occur if the knee is kept in plaster for 6 months.*

Later there may also be giving way or locking. Operation is then necessary. If the fragment is loose it is excised.

Elbow (*capitellum, see* page 131) — "Splitting" osteochondritis of the elbow rarely presents until the loose body has separated to give locking, or still later with osteoarthritis. X-rays show an irregular cyst-like appearance in the capitellum, a large radial head and a loose body which may, however, be apparent only in the lateral view. On the rare occasions when the patient is seen before separation has occurred, the joint is rested in a splint. Later, loose bodies may need to be removed.

DYSPLASIA — Minor developmental errors may, by subjecting the capsule to undue strain, predispose to blood-vessel injury.

INFECTION — This has been put forward as a possible explanation in pseudocoxalgia, because a few patients are pyrexial, and staphylococci have on occasion been cultured; but most patients have no fever and the pathology is unlike that of an infection.

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CHAPTER 6

BONE DYSTROPHIES AND DYSPLASIAS

STRICTLY SPEAKING, dystrophy means faulty nutrition and dysplasia means faulty development. Tradition, however, has sanctioned a wider use of both terms and in this chapter a considerable range of disorders, many of them rare, will be discussed under the following convenient headings: Congenital disorders—general—local: Acquired disorders—general—local.

I: GENERAL CONGENITAL DISORDERS

Under this heading are included some conditions in which the clinical manifestations are not present at birth, even though the underlying fault is. The causes in all this group are unknown.

BRITTLE BONES (OSTEOGENESIS IMPERFECTA)

PATHOLOGY

This is usually a familial disorder, characterized by many fractures, due to increased fragility of the bones. Metabolic and endocrine studies have so far not explained the extraordinary bone fragility. Osteoblasts are too few in number or poor in quality, so that there is imperfect formation and calcification of bone trabeculae. Other mesenchymal derivatives may also be involved, with, for example, abnormal ligaments and sclerae.

CLINICAL FEATURES

Many fractures occur either before birth or in infancy, becoming fewer as the child grows older. In rare cases, the first fracture does not occur for several years.

The skull is broad, the sclerotics often deep blue in colour, and otosclerosis, with deafness, may develop in the fourth decade. Most patients are stunted, due partly to spinal deformity (kyphosis and scoliosis) and partly to gross deformity of the lower limbs. The limb deformity results from mal-union of fractures and bending of soft bone (the bone softening may be primary, or due to prolonged recumbency enforced by the repeated fractures). There may also be ligamentous laxity. Blood chemistry is usually normal.

The fractures are frequently greenstick in type and unite rapidly with routine treatment. Very occasionally, in the femur, a tremendous excess of callus is produced (hyperplastic callus).

Ankle (*talus*) — The patient may complain of locking from a loose body, or pain, swelling and stiffness from osteoarthritis. If seen early, the fragment, which separates from one corner of the upper surface of the talus, may be excised. A severely osteoarthritic ankle may need arthrodesis.

"PULLING" OSTEOCHONDRITIS (TRACTION)

CAUSE

TRAUMA — Traction injury to an apophysis is almost certainly the responsible cause.

OTHER THEORIES — It has often been asserted, without evidence, that the condition is analagous to the other types of osteochondritis.

PATHOLOGY

Following excessive strain on a powerful tendon, the apophysis to which it is attached becomes fragmented and irregular in appearance. The x-ray changes are not easy to demonstrate convincingly because a normal apophysis often looks irregular shortly before it fuses with the parent bone.

REGIONAL SURVEY OF "PULLING" OSTEOCHONDRITIS

The knee is much the commonest site; occasionally the heel is affected.

Knee (*Osgood-Schlatter's disease, see* page 221) — Children aged between 10 and 15 years are affected. The tibial tubercle is swollen and tender, and extension of the knee against resistance sometimes hurts. X-rays show irregular fragmentation of the apophysis into which the patellar ligament is inserted. The disease may be bilateral.

Spontaneous recovery usually occurs and it is necessary only to curtail the child's activities, especially cycling and soccer. If pain persists, a straight plaster tube is worn for 2 months. Drilling fine holes through the apophysis accelerates fusion but carries the risk of causing a hyperextending knee.

Rarely, similar changes affect the lower pole of the patella (Johansson-Larsen's disease) and even more rarely the whole patella is said to be involved.

Heel (*Sever's disease, see* page 237) — This presents in a child aged about 10 years with a painful, tender heel. X-rays show increased density and sometimes fragmentation of the apophysis into which the tendo achillis is inserted. Quite often the unaffected heel shows identical changes. The only treatment necessary is to see that the child avoids wearing flat-heeled shoes.

Suggestions for further reading

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though often curved, is usually of normal structure. The epiphysis may be mottled or streaky. The pelvis may show translucent lines radiating like a fan. The fingers nearly always show multiple chondromata with stippled calcification.

ACHONDROPLASIA

PATHOLOGY

In this not uncommon disease there is occasionally a family history. Cartilage cells produced by the epiphyses fail to line up regularly and undergo degeneration. Periosteal bone formation may be excessive.

CLINICAL FEATURES

The child may die *in utero* or soon after birth, especially if born prematurely. If he survives the first year he becomes a dwarf with normal intelligence and often excellent musculature.

The skull is large and brachycephalic, with bulging vault and forehead, and a flat nose. The trunk is a little short, but the limbs grossly short, so that the hands do not reach the buttocks and the patient may be able to kiss his toes while keeping his knees straight. The fingers also are short and stubby, being unusually equal in length. All these features, together with prominent buttocks, account for the popularity of achondroplasiacs as circus dwarfs.

X-RAY APPEARANCES

The bones are short and thick, with prominent muscle markings. Their ends appear splayed and the epiphyses may show a central V-shaped notch. The pelvis is too small for normal delivery.

CHONDRO-OSTEO-DYSTROPHY (MORQUIO-BRAILSFORD DISEASE)

PATHOLOGY

This disease is familial but its pathology is unknown.

CLINICAL FEATURES

Development is apparently normal until the end of the first year of life. The patient becomes a dwarf, chiefly because of the gross kyphosis, which is sometimes acute and angular. The limbs are relatively long and the epiphyses often enlarged. Usually there is joint stiffness with deformities, especially fixed flexion of the hips and knees. The skull and face are normal, but the head pokes forwards.

X-RAY APPEARANCES

The vertebrae are too flat (platyspondyly), narrower in front than behind (tongued), and have irregular borders. At the apex of the kyphosis one vertebral body may be shifted backwards. The acetabulum is large and irregular so that

X-RAY APPEARANCES

The shafts of long bones are osteoporotic, bent and slender; the bone ends, however, appear large and are sometimes cystic. The vertebral bodies, being soft, are biconcave, and the pelvis often triradiate.

MULTIPLE EXOSTOSES (DIAPHYSEAL ACLASIS)

PATHOLOGY

This is a familial disorder, commoner in males. There is failure of bone remodelling; as the bone grows in length the excess metaphyseal bone is not moulded away. The excess bone protrudes through the periosteum forming squat exostoses.

CLINICAL FEATURES

Often the patient is short, and has multiple lumps. Common sites are around the knee, the upper humerus, the fibula and the lower end of radius and ulna. (As with most dysplasias, the elbow is spared.) Epiphyses are not affected and the middle third of the shaft only rarely. Occasionally flat bones also are affected. Unlike in dyschondroplasia the fingers are normal or have only tiny knobs. The lumps may interfere with tendon action. Usually they stop growing when the parent bone does; but rarely a lump continues to grow, forming a chondromatous mass, and malignant change has been reported.

X-RAY APPEARANCES

Metaphyseal exostoses are seen. They are broad, sessile and irregular (unlike the elegant conical solitary osteoma).

DYSCHONDROPLASIA (OLLIER'S DISEASE)

PATHOLOGY

This disease is rare and is not familial. Ossification of cartilage at the growth discs is faulty, islands of cartilage remaining unossified within the shaft (not on its surface as in diaphyseal aclasis).

CLINICAL FEATURES

Often the disease is predominantly unilateral, the affected limb being short, and, because the metaphysis contains irregularly distributed islands of cartilage, there is deformity. Common deformities are valgus at the knee and ankle, and relative shortening of the ulna so that the radius is curved and sometimes dislocated. The fingers or toes frequently contain multiple enchondromata, which are characteristic of the disease.

X-RAY APPEARANCES

Large translucent islands or columns of cartilage are seen in a ballooned metaphysis. As the child grows these islands develop irregular dense spots. The shaft,

though often curved, is usually of normal structure. The epiphysis may be mottled or streaky. The pelvis may show translucent lines radiating like a fan. The fingers nearly always show multiple chondromata with stippled calcification.

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PATHOLOGY

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The bones are short and thick, with prominent muscle markings. Their ends appear splayed and the epiphyses may show a central V-shaped notch. The pelvis is too small for normal delivery.

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The vertebrae are too flat (platyspondyly), narrower in front than behind (tongued), and have irregular borders. At the apex of the kyphosis one vertebral body may be shifted backwards. The acetabulum is large and irregular so that

dislocation may occur. The femoral head is flat and fragmented and the neck varus. The other long bones also often have large irregular fragmented epiphyses, but the shafts are usually normal.

GARGOYLISM (HURLER'S DISEASE)

Gargoylism, a skeletal disorder combined with a disturbance of lipid metabolism, is a variant of chondro-osteo-dystrophy with the following differences: the face is coarse and ugly, often there are corneal opacities, and mental defect is common. The hips are valgus rather than varus, and the vertebral bodies are not flat but biconvex.

EPIPHYSEAL DYSPLASIA

PATHOLOGY

This rare disease is not familial. In its usual form (multiplex) many major epiphyses are affected.

CLINICAL FEATURES

The patient looks stunted because the limbs are short. The face, skull and spine are normal.

X-RAY APPEARANCES

The epiphyses are irregular in shape and slightly mottled. In time their architecture becomes normal but not their shape, so that stiffness and deformity may persist.

DYSPLASIA EPIPHYSEALIS PUNCTATA

Dysplasia epiphysealis punctata is a variant of the above condition in which the epiphyses are more stippled.

DIAPHYSEAL DYSPLASIA (ENGELMANN'S DISEASE)

There is fusiform enlargement and sclerosis of the shafts of long bones; often the femur, tibia and forearm bones are symmetrically affected. The patient may have limb pain, weakness or a peculiar gait.

INFANTILE CORTICAL HYPEROSTOSIS (CAFFEY'S DISEASE)

CAUSE

This rare disease is not developmental but possibly due to a virus infection.

CLINICAL FEATURES

An infant under 6 months old develops swellings, which may be tender, on the mandible, long bones and sometimes the scapula. Often there is fever. Spontaneous recovery is the rule.

The condition should not be confused with osteomyelitis, which is never so widespread, nor with scurvy, which occurs in older infants and is associated with anaemia and bleeding disorders.

X-RAY APPEARANCES

Subperiosteal new bone formation is seen on the affected bones.

CLEIDO-CRANIAL DYSOSTOSIS (ANOSTEOPLASIA)

PATHOLOGY

In this familial condition there is faulty development of membrane bones, chiefly the clavicles and skull.

CLINICAL FEATURES

The patient is somewhat short, with a large head, flat-looking face and drooping shoulders. The teeth appear late and develop poorly. Because the clavicles are partly absent, the patient can bring his shoulders together in front of the chest. Spinal curvature and widening of the symphysis pubis are not uncommon. The hands are curious in that the index finger is often too long, while the terminal phalanx of the thumb (or other fingers) is too short. The mentality is normal.

X-RAY APPEARANCES

Part of each clavicle is absent, usually the outer half, sometimes the middle third, and, rarely, the inner quarter. The pubis usually shows deficient ossification, and the hips sometimes show coxa vara. Spina bifida occulta is common.

SPIDER FINGERS (ARACHNODACTYLY)

In this familial disease, the fingers and toes are too long. The patient is tall, thin and dolichocephalic, with hypermobile joints and weak muscles. Eye defects and congenital heart disease often occur.

MARBLE BONES (ALBERS-SCHÖNBERG DISEASE)

In this familial disease the bones are excessively dense. They may be tremendously hard and are sometimes too brittle. Because there is little true medulla, aplastic anaemia is common. Cranial nerves may be compressed by narrowing of the foramina. X-rays show very dense, almost structureless bone.

CANDLE BONES (MELORHEOSTOSIS)

This condition, which is not familial, has been considered to be a localized form of marble bones. This is unlikely, because it may present with pain and with limited movement, and because the outline of the bone is irregular.

dislocation may occur. The femoral head is flat and fragmented and the neck varus. The other long bones also often have large irregular fragmented epiphyses, but the shafts are usually normal.

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The patient looks stunted because the limbs are short. The face, skull and spine are normal.

X-RAY APPEARANCES

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CLINICAL FEATURES

An infant under 6 months old develops swellings, which may be tender, on the mandible, long bones and sometimes the scapula. Often there is fever. Spontaneous recovery is the rule.

Note — A bony abnormality of the spine often has a tell-tale overlying abnormality of the skin, for example a naevus or a patch of hair.

UPPER LIMB

Sprengel's shoulder and Klippel-Feil syndrome — These are discussed on page 117.
Radio-ulnar synostosis — This results in absence of pronation and supination, which is compensated for by movement at the shoulder and wrist. X-rays show the upper one inch of both bones joined to[illegible] joined to the radio-uln[illegible]
Absence of the [illegible]viation of the carpus, and an absent thumb. The wrist deformity should be corrected by manipulation and splintage.
Missing fingers — One or more fingers may be missing. The least rare anomaly is "lobster hand", with a thumb and only one finger. Function is astonishingly good. More than one limb may show the lobster deformity and the condition is familial.
Extra digits — These are rare but may need amputation for cosmetic reasons. Polydactyly may be part of a widespread developmental disorder (for instance, Laurence-Moon-Biedl syndrome, or chondroectodermal dysplasia).
Syndactyly or webbed fingers — These may be primary, secondary, or acquired.

(*a*) Primary dysplasia is often familial; not only is the skin webbed, but the bones may be joined. Treatment is not often successful.

(*b*) Secondary deformity is possibly due to amniotic adhesions. This variety is not familial. The web is wide, and the bones are not joined. Plastic surgery often effects a satisfactory separation.

(*c*) Acquired syndactyly may follow burns and requires treatment by Z-plasty, skin flaps or grafts.

LOWER LIMB

Congenital dislocation of the hip — This is discussed on page 189 and congenital subluxation on page 193.
Absence of the upper part of the femur — This is rare and the child presents with a very short leg. The "absent" part may in fact be cartilaginous, and it is worth applying skin traction to reduce shortening while ossification is awaited.
Absence of the fibula — This is associated with a short forwardly bowed tibia, an equinovalgus foot and absence of the fifth toe. The foot should be kept plantigrade by manipulation and splintage
Absence of the tibia — This is exceedingly rare and amputation is almost inevitable.
Congenital pseudarthrosis of the tibia — This is probably a localized bone dysplasia rather than non-union of a fracture. The child is born with a fracture, or with a bowed tibia which breaks on walking. The bowing and the fracture are always in the lower third. Formerly massive grafts with screws and prolonged fixation occasionally resulted in union, but often the leg was amputated after many failures. MacFarland's operation has vastly improved the outlook The angulation is disregarded and a large bone graft inserted posteriorly from well above to well below the pseudarthrosis.
Talipes equino-varus — This is the most important of the many varieties of congenital club foot (*see* page 232).
Other foot conditions — Extra toes, absent toes and syndactyly occur as in the hand.

Usually, one limb is affected. A part or the whole of the bone is irregularly thickened by a line of increased density. The appearance is reminiscent of the wax which congeals on the side of a burning candle.

RADIOLOGICAL CURIOSITIES

Two rare conditions with an unusual x-ray appearance but no abnormal clinical features are the following.

Striped bones (osteopathia striata) — Lines of increased density run parallel to the shafts of long bones. In the pelvis they radiate from the acetabulum.

Spotted bones (osteopoikilosis) — There are multiple small dense spots in the cancellous portion of many bones.

II: LOCAL CONGENITAL DISORDERS

These disorders may be classified into primary and secondary groups.

Primary

Faulty segmentation — This group includes: fusion of segments (for instance, fused vertebrae); faulty levels (for instance, Sprengel's shoulder), additional segments (for instance, an extra digit).

Faulty ossification — This group includes: incomplete ossification (for instance, spina bifida); complete absence of bone (for instance, absent fibula).

Secondary

The term "secondary" implies that, although there may be an underlying dysplasia, the deformity is partly the result of pressure; for example, club foot or dislocated hip.

ANATOMICAL SURVEY

The above classification is academic. In practice it is more useful to consider the commoner congenital deformities regionally.

TRUNK

NECK

Cervical rib (*see* page 158).

Torticollis — This is probably not a true congenital deformity (*see* page 153).

Fusion of cervical vertebrae — This occasionally occurs, but is not noticed unless other deformities are present, as in Klippel-Feil syndrome.

REST OF SPINE

Spina bifida, occulta or manifesta (*see* page 162)

Spondylolysis and spondylolisthesis (*see* page 183).

[illegible]

[illegible] *a transitional fifth lumbar vertebra* — These [illegible] whether they cause symptoms.

ADULT RICKETS (OSTEOMALACIA)

Adult rickets may follow gross malnutrition especially in pregnancy; it also occurs in idiopathic steatorrhoea. The bones ache, soften and bend. X-rays show gross decalcification and a triradiate pelvis. Occasionally the long bones may also show multiple symmetrical translucent bands (Looser's zones) or fine cracks which look like spontaneous fractures (Milkman's syndrome).

COELIAC RICKETS

It is now known that coeliac rickets is due to gluten, a protein which is noxious to a few children. On a diet from which wheat, rye and oats are completely excluded they lose the abdominal distension, wasting, anaemia and irritability; the fatty stools become normal, the signs of rickets disappear and the child thrives and grows.

RENAL RICKETS (RENAL OSTEODYSTROPHY)

CAUSE

The renal tubules and glomeruli do not function normally (the term "renal rickets" is best restricted to such total kidney involvement). This may result from congenital cystic kidney or chronic nephritis.

PATHOLOGY

Serum phosphorus levels increase because the kidney is unable to excrete it. The excess phosphorus is excreted in the gut where it combines with calcium. As the blood phosphate level rises the calcium level falls; consequently excess parathormone is secreted and calcium-deficiency rickets results.

CLINICAL FEATURES

The child is stunted, pasty faced and anaemic. Deformities occur as in infantile rickets.

X-RAY APPEARANCES

The bones may show changes similar to infantile rickets. More often the bones are not decalcified, but the epiphyses look as if they are slipping off the shafts.

TREATMENT

The kidney condition is treated and vitamin D given. Even though there may be gross genu valgum, operation is best avoided, for it may provoke a uraemic crisis. These children eventually die of uraemia.

RENAL TUBULE RICKETS

CAUSE

The kidney disorder is part of a general metabolic disturbance such as Fanconi's syndrome or one of the "cystinoses". The glomeruli excrete phosphorus, but

III: GENERAL ACQUIRED DISORDERS—(A) DUE TO FAULTY DIET OR METABOLISM

INFANTILE RICKETS

CAUSE

Rickets is due to insufficient vitamin D, which results from inadequate diet or insufficient exposure to sunlight. Because of lack of vitamin D, calcium and phosphorus absorption is reduced. Compensatory parathyroid secretion increases, calcium is not deposited in bones and may even be withdrawn.

PATHOLOGY

The growth disc produces abundant cartilage, but this is not converted to bone. Ossification and growth are retarded and the soft bones bend.

CLINICAL FEATURES

The infant is fretful, restless, liable to bronchitis and diarrhoea, and may (if the blood calcium level is low) have convulsions. In marked cases, the skull is bossed ("hot-cross-bun head"), dentition is delayed and the costochondral junctions are enlarged ("rickety rosary"). There is a smooth kyphosis, lax ligaments and flabby muscles.

The limbs show enlargement of the bone ends, and deformities due to bending of soft bones, especially in the lower limbs if the child has walked (coxa vara, bowed femora, knock knees and bow legs). The soft bones may crack with trivial injury. Serum calcium level is usually normal, phosphorus low, and alkaline phosphatase high.

X-RAY APPEARANCES

There is general decalcification, growth discs which are too deep, and metaphyses which are too wide.

TREATMENT

The administration of vitamin D effects a rapid cure. The child is rested until the bones harden. Later, osteotomy may be required.

RESISTANT RICKETS

"Vitamin-D-resistant rickets" occurs in those few children and adolescents with hypophosphataemia who need massive quantities of vitamin D for normal bone formation. The patients are short in stature and easily fatigued. They develop severe deformities. In England nowadays resistant rickets is much commoner than [illegible] of the grossly bent bones seen in adults (other than [illegible] yphilis) are the late effects of resistant rickets. The

CLINICAL FEATURES

Adults are affected, chiefly women. The patients are listless, with flabby muscles, and are sometimes bedridden. The bones are painful and often bend. Fractures of the long bones are common, as are kidney stones and pyelitis.

X-RAY APPEARANCES

[illegible] not visible.

TREATMENT

The parathyroid adenoma or part of the hyperplastic tissue should be removed.

SENILE OSTEOPOROSIS

With the increased expectation of life in modern times, senile osteoporosis is becoming a serious problem.

CAUSE

The cause is unknown. Endocrine involution may be a factor and it is also possible that the relative inactivity of ageing persons plays a part.

PATHOLOGY

The bones are soft and osteoporotic with a lack of osteoid tissue.

CLINICAL FEATURES

The patients are usually women, often thin and kyphotic. Fracture of a thoracic or lumbar vertebra is common, with pain. A fractured neck of femur often occurs in senile osteoporosis.

X-RAY APPEARANCES

The widespread osteoporosis is readily seen in the spine, where the soft vertebral bodies are indented by the discs and become biconcave. One or more vertebrae are often wedged because of fracture.

TREATMENT

Senile osteoporosis cannot be prevented. Its effects can possibly be minimized by ensuring that the ageing are kept active as far as possible and given adequate protein, calcium and phosphorus. In treatment, endocrine extracts are sometimes used. High-voltage x-ray therapy has been used for the back pain. Vertebral fractures are treated like any other stable spine fractures.

normal reabsorption through the tubules does not occur, so that the serum phosphorus falls. Consequently serum calcium increases, calcium being withdrawn from bone.

CLINICAL FEATURES

There is a hereditary factor. The child is dwarfed and has gastrointestinal upsets. There is polyuria, with sugar, amino-acids and sometimes cystine in the urine. Rickety changes are also present.

INFANTILE SCURVY

CAUSE

The diet is deficient in vitamin C.

PATHOLOGY

Cartilage calcifies but does not form normal osteoid tissue.

CLINICAL FEATURES

The infant is a poor specimen, irritable, pale, undernourished, anaemic and, in severe cases, with spongy gums. Subperiosteal haemorrhages occur with pain, swelling and extreme tenderness. Rickets may coexist. Fractures and epiphyseal separations may occur and they heal slowly.

TREATMENT

Large doses of vitamin C are given in concentrated form.

IV: GENERAL ACQUIRED DISORDERS—(B) ENDOCRINE DISORDERS

HYPERPARATHYROIDISM (VON RECKLINGHAUSEN'S DISEASE)

CAUSE

Too much parathormone is secreted, usually by a parathyroid adenoma.

PATHOLOGY

Because of parathyroid oversecretion the kidneys excrete excess phosphorus, which lowers the serum phosphorus level. To restore the calcium-phosphorus balance, calcium is withdrawn from bone, raising the serum calcium level; and this leads to the formation of renal calculi. There is a negative calcium balance, and it is said that hyperparathyroidism is the only condition in which increased serum calcium is unaffected by giving cortisone.

PATHOLOGY

Bone lamellae are continually being absorbed by osteoclasts, and new ones laid down by osteoblasts. If this process is faulty a bone defect results which may be filled with fluid or fibrous tissue, and the fibrous tissue may calcify. The walls of the defect or "cyst" contain giant cells and on microscopy resemble osteoclastomata.

CLINICAL VARIETIES

The faulty process may affect part of a bone, the whole of a bone, or several bones. The more important clinical types are described.

SOLITARY CYST OF BONE — This usually occurs in the upper humerus, femur, or tibia, but other bones may be affected. Solitary cysts are seen in children up to the age of puberty and after that become increasingly rare. Clinically a cyst presents with local ache, or as a pathological fracture.

X-rays show a translucent area on the shaft side of the growth disc. It is rounded, has a clearcut edge but no surrounding sclerosis (for differential diagnosis *see* pages 4–5).

Because cysts are hardly ever seen in adults, it is presumed that many disappear spontaneously. A fracture through a cyst often results in the cyst becoming obliterated. If the cyst is troublesome or increasing in size it should be evacuated, the wall scraped and the cavity filled with bone chips.

MONOSTOTIC FIBROUS DYSPLASIA — This condition is much rarer than solitary cyst. The architecture of the whole of a long bone is altered, the lamellar pattern being replaced by irregular cysts and patchy sclerosis. The cysts contain tough fibrous tissue which may be calcified, in which case the bone may not bend.

The patient is usually in his "teens" and complains of a vague ache. High-voltage x-ray therapy has been used with doubtful results. If necessary the shaft may be guttered.

POLYOSTOTIC FIBROUS DYSPLASIA — The major long bones are chiefly affected, often only in one limb, sometimes in one half of the body; sometimes lesions are scattered throughout the skeleton.

Patients may present with bone enlargement, deformity, pain or a fracture. (Fractures are common, but unite normally.)

X-rays show cystic areas and patches or streaks of increased density in the shafts (not the epiphyses) of long bones. The short bones often show a uniform ground-glass appearance; the skull may be irregularly thickened with numerous dense spots.

The x-ray appearance in polyostotic fibrous dysplasia differs from that of hyperparathyroidism, in which the bones are markedly osteoporotic.

Albright's disease is a combination of polyostotic fibrous dysplasia with skin pigmentation and sexual precocity, usually occurring in girls. Blood calcium and phosphorus levels are normal, but the serum phosphatase level is high.

PAGET'S DISEASE (OSTEITIS DEFORMANS)

CAUSE

The cause of this common disease is completely unknown. Infection, metabolic errors or endocrine disorders have been suggested but with no convincing evidence.

CLIMACTERIC OSTEOPOROSIS

This useful term serves as a reminder that changes similar to those of senile osteoporosis not uncommonly occur in younger people aged 50–60 years. Endocrine withdrawal is clearly to blame, and administration of pituitary or gonadal extracts is valuable. With these, and ordinary treatment of any fracture, the patient can be restored to relatively good health and it then becomes obvious that there is no true senility.

OTHER ENDOCRINE DISORDERS

Many other endocrine disorders affect the skeleton. They include pituitary gigantism, acromegaly, pituitary dwarfism and Cushing's syndrome.

Of special orthopaedic interest is Fröhlich's syndrome, in which adiposity and sexual retardation may be combined with slipping of the upper femoral epiphyses (*see* page 200).

V: GENERAL ACQUIRED DISORDERS—(C) MULTIPLE DEPOSITS

Although multiple deposits are not dystrophies or dysplasias, it is convenient to summarize them here.

Hand-Schüller-Christian disease — There are multiple deposits in the bones, especially the skull (showing as sharply-defined translucent areas on x-ray), in the pituitary gland (causing diabetes insipidus) and in the orbit (causing exophthalmos).

Gaucher's disease — The haemopoietic tissues are affected, with deposits in bone (usually osteolytic, occasionally osteoblastic), and enlargement of lymph nodes and spleen. Vertebral fractures may occur.

Leukaemia — The bones may show diffuse areas of rarefaction but more often a patchy sclerosis. There is also anaemia, enlargement of the spleen, liver and lymph nodes and often haemorrhages in the skin or alimentary tract.

Multiple myeloma and secondary carcinoma — These are dealt with in the section on Bone Tumours.

VI: ACQUIRED DISORDERS WHICH MAY BE EITHER LOCAL OR GENERAL

FIBROUS DYSPLASIA (FIBROCYSTIC DISEASE)

CAUSE

In almost all cases the cause is unknown. Localized fibrous dysplasia has been ascribed to haemorrhage in bone or to a benign neoplasm. Some forms of generalized fibrous dysplasia are associated with endocrine disorder.

TREATMENT

No specific treatment for the disease is known. Analgesics are, of course, needed for the pain. Occasionally it is worthwhile to osteotomize a painful bent bone and to put it straight. Formerly operations such as guttering the bone, periosteal stripping or tying the nutrient artery were advocated; these have been abandoned.

Fractures unite with ordinary treatment: in the vascular stage union is rapid, in the sclerotic stage very slow. Internal fixation can be used but in the vascular stage bleeding is considerable, and in the sclerosed stage the bone is very hard and brittle.

Suggestions for further reading

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PATHOLOGY

As in fibrous dysplasia there is a fault in the process of bone absorption and re-formation. In the so-called vascular stage, the spaces left by bone absorption fill with vascular fibrous tissue. On both sides of the cortex new osteoid tissue forms, but it is not converted to mature bone; hence, although thick, the bone is soft and bends. Moreover, the new lamellae are not regularly arranged so that later (in the so-called sclerotic stage) even though the lamellae calcify and become thick and sclerosed, the bone is easily broken.

CLINICAL FEATURES

The patient is usually aged 50–70 years, though occasionally the disease appears at a much earlier age. It may for many years remain localized to part or the whole of one bone, the pelvis and tibia being the commonest sites, the femur, skull, spine and clavicle the next commonest.

An affected bone may be painful. It looks bent and thick and feels warm. (Paget's disease is the sole cause of a thick, bent bone.)

In generalized Paget's disease, the patient may have few symptoms but a wide variety of distressing symptoms can occur: headache, deafness, deformities, stiffness, limb pain and sometimes fractures and heart failure. The skull enlarges so that bigger hats are required. Otosclerosis may produce deafness and occasionally pressure on the optic nerve produces blindness. There is considerable kyphosis so that the patient becomes shorter and apelike, with bent legs and his arms hanging in front of him. Backache and root pain are common. There is slight coxa vara, and considerable anterolateral bowing of the legs. When the disease extends up to a joint surface, that joint is usually stiffish and deformed. The only constant abnormality of blood chemistry is that the alkaline phosphatase level is considerably increased.

X-RAY APPEARANCES

The bone as a whole is thick and bent; its density in the vascular stage is decreased and in the sclerotic stage increased. The trabeculae are coarse and widely separated, giving a streaky or honeycomb appearance. The thick cortex often shows, on its convex aspect, fine subperiosteal cracks probably resulting from stress; the junction of cortex and medulla is indistinct. Where only part of a bone is affected, the junction of normal and abnormal bone often looks cystic.

COMPLICATIONS

High-output cardiac failure is not uncommon, and is thought to be due to arterio-venous shunts in the vascular bone.

Fractures are not uncommon, especially in the upper femur and upper tibia.

Sarcoma is rare (published figures vary from 1 to 11 per cent), and presents with increased pain and swelling of an affected bone.

The tumour is conical; it arises by a broad base from normal bone, points away from the growing end, and is expanded at its tip where there is a cartilage cap.

Spread is only local and the tumour stops growing when bone growth ceases.

CLINICAL FEATURES

An adolescent presents with a painless lump at the growing end of a long bone, the knee being a favourite site. Although the lump is bony hard, it may be covered by a bursa. Occasionally the lump interferes with tendon action.

X-RAY APPEARANCES

The texture is that of normal bone; the medulla and cortex of the tumour are continuous with the parent bone via a broad base at the metaphysis. The cartilage cap is invisible.

DIFFERENTIAL DIAGNOSIS

In diaphyseal aclasis there are multiple exostoses; the metaphysis looks irregular on x-ray and there are several squat knobs of bone rather than one elegant cone (*see* page 46).

TREATMENT

If it is causing trouble the osteoma is excised.

PROGNOSIS

Malignancy probably does not occur.

COMPACT OSTEOMA (IVORY EXOSTOSIS)

PATHOLOGY

This rare tumour is said to arise from precartilaginous cells of the epiosteum. Microscopically only normal bone cells are seen. Macroscopically the tumour is a squat sessile knob of ivory-hard bone. It does not metastasize.

CLINICAL FEATURES

An adolescent or a young adult presents with a lump. The commonest site is the outer surface of the skull, where the only symptom is of a hard, painless lump. The tumour may occasionally occur on the inner surface of the skull, and then give rise to focal epilepsy.

X-RAY APPEARANCES

A sessile plaque of exceedingly dense bone with a well-circumscribed edge is seen.

TREATMENT

The tumour is best excised. It is so hard that a small area of surrounding normal bone must be excised with the tumour.

CHAPTER 7

BONE TUMOURS

CLASSIFICATION

THERE are many classifications; that employed in the following account is based on two factors.

(1) *Is the tumour benign or malignant?* — A benign tumour remains local; from a malignant tumour, cells migrate to distant sites where they grow parasitically.
(2) *Which cell gives rise to the tumour?* — It is convenient to consider three groups of cells from which a tumour may arise.

(*a*) "Framework" cells: bone, cartilage and periosteum which form the basic structure of bone.

(*b*) "Resident" cells: spindle cells, fibrous tissue, fat, blood and reticuloendothelial cells which are normally found in bone, even though not of its basic structure.

(*c*) "Invaders": *malignant cells from other tissues which may be carried to and* deposited in bone.

Benign tumours may arise from (*a*) framework cells—osteoma, chondroma, osteochondroma; (*b*) resident cells—giant-cell tumours, fibroma, lipoma, angioma.
Malignant tumours may arise from (*a*) framework cells—osteogenic sarcoma, chondrosarcoma, periosteal fibrosarcoma; (*b*) resident cells—Ewing's tumour, myeloma; (*c*) invaders—secondary carcinoma.

Of the malignant tumours, groups (*a*) and (*b*) are primary and group (*c*) is secondary.

BENIGN TUMOURS

Probably most benign tumours arise from precartilaginous cells (Geschickter and Copeland, 1949) which may give rise predominantly to bone (osteoma), to cartilage (chondroma), or to bone and cartilage (osteochondroma). Nearly all benign tumours occur in adolescents or in young adults, and, with the exception of benign giant-cell tumours, stop growing when bone growth is complete. Their benign character is displayed on x-ray by their clearly-defined edges.

CANCELLOUS OSTEOMA (EXOSTOSIS)

PATHOLOGY

A cancellous osteoma arises from precartilaginous cells and consists of ordinary bone and cartilage cells. It is probably only a minor disorder of growth.

CLINICAL FEATURES

The *patient is usually* adolescent and the tumour occurs in one of the short pipe bones—metacarpals, metatarsals or proximal phalanges.

Usually the patient presents with a fracture after trivial injury. Occasionally he may present with a swelling.

X-RAY APPEARANCES

The tumour shows as a rarefied area *in the medulla, characteristically with* speckled calcification. The cortex is ballooned and thin, but remains intact until a fracture occurs.

DIFFERENTIAL DIAGNOSIS

A solitary cyst, when it occurs in a short bone, may be indistinguishable from a chondroma, but it never shows speckled calcification. Multiple chondromata occur, especially in the fingers, in dyschondroplasia.

TREATMENT

The tumour and its capsule should be excised, and if necessary a bone graft or bone chips inserted.

PROGNOSIS

Malignancy does not occur.

LONG-BONE CHONDROMA

This rare tumour is often called a benign chondroblastoma. It occurs at the end of a long bone in a young adult and presents as a constant ache. X-rays show a localized area of irregular calcification.

The tumour should be excised to confirm the diagnosis and cure the condition.

NOTE — Some authorities describe chondromata of the flat bones (pelvis, scapula). These tumours are more often osteochondromata and will be considered under that heading.

OSTEOCHONDROMA

PATHOLOGY

The tumour arises from precartilaginous cells. On section, areas of normal bone and cartilage cells are seen. Macroscopically, a big, *lobulated*, cauliflower-like mass arises from a wide base and is covered by a cap of cartilage.

CLINICAL FEATURES

The patient is usually aged 10–25 *years*. He presents with a large lump which is painless, although occasionally there may be slight ache or interference with the

PROGNOSIS

Malignancy does not occur.

OSTEOID OSTEOMA

Osteoid osteoma was first described by Jaffe in 1953. Since then many cases have been recorded in the literature.

PATHOLOGY

The origin of this tumour is unknown. Microscopically it consists of osteoid tissue with trabeculae of newly formed bone, in a vascular connective tissue groundwork. It is a small tumour, usually less than 1 centimetre in size, round or oval in shape, and surrounded by dense bone.

CLINICAL FEATURES

Osteoid osteoma is most commonly seen in patients aged 10–25 years, though it does occur in older people. It is commoner in males. Any bone except the skull may be affected but over half the cases occur in the femur or tibia. The spine is a not uncommon site.

The only symptom is pain, which is sometimes severe and is not relieved by rest. Often the pain continues for many months, and until the x-ray appearances were fully described, many patients were judged to be hysterical. Localized tenderness of bone is usually present.

X-RAY APPEARANCES

The most striking feature is a small area of dense sclerosis. If the tumour is in cortex, the overlying periosteum is visibly raised and is also sclerosed. In the centre of the dense area is a tiny opaque nidus which is often difficult to demonstrate on x-ray.

DIFFERENTIAL DIAGNOSIS

It is sometimes difficult to distinguish an osteoma from a small Brodie's abscess without biopsy. A Ewing's tumour and chronic periostitis must also be excluded (*see* page 11).

TREATMENT

Excision of the affected area cures the pain and the condition does not recur.

SHORT-BONE CHONDROMA

PATHOLOGY

The tumour arises from precartilaginous cells and consists only of normal cartilage cells. It is within the bone, well encapsulated and remains local. It is lobulated, and the septa may calcify irregularly. (Some authorities also describe an ecchondroma which grows outside the bone.)

the time it is seen clinically, it is nearly always at the end of a bone. Occasionally the jaw is affected, and rarely tendon sheaths.

The usual presenting symptom is vague discomfort, sometimes with slight swelling. A history of trauma is not uncommon and pathological fracture occurs in 10–15 per cent of cases.

On examination, there is a vague swelling of the end of a long bone. (Egg-shell crackling is rare nowadays because of early diagnosis.) The neighbouring joint is often irritated.

X-RAY APPEARANCES

The tumour shows as an extremely rarefied area situated asymmetrically at the end of a long bone, often with trabeculae and a "soap-bubble" appearance. There is a sharp, clearly-defined line of junction with the rest of the bone. The cortex is very thin and sometimes ballooned, but is intact unless a fracture has occurred.

TREATMENT

CONSERVATIVE — The tumour often responds well to small doses of irradiation (2,000r), especially if marked trabeculation is present. X-rays show further decalcification for the first 6–8 weeks, after which the bone appears to re-form. In large tumours, treatment may have to be repeated after 6–12 months.

OPERATIVE — Local excision and curettage is usually inadequate, because 30 per cent of cases recur.

Complete resection with a normal margin of bone gives only a 6 per cent recurrence, but destroys the joint, which usually needs to be arthrodesed.

Rarely, amputation may prove necessary.

OTHER BENIGN TUMOURS

HAEMANGIOMA — This is said to be frequently seen in vertebrae at post-mortem examination, but clinically it is very rare. In the pipe bones a haemangioma usually presents as a pathological fracture. X-rays show a shaggy trabeculated tumour expanding the bone.

FIBROMA — This may occur in the subperiosteal layer where it cannot be diagnosed without biopsy. Some authorities describe a "non-osteogenic fibroma of bone" which is possibly the same thing as a benign chondroblastoma. Most so-called fibromas are really part of a fibrous dysplasia.

SUBPERIOSTEAL LIPOMA — A subperiosteal lipoma is rare but can be diagnosed on x-ray because of its extreme translucence

DEPOSITS — Deposits in bone may occur in conditions such as Hand-Schüller-Christian disease, Gaucher's disease and eosinophilic granuloma. In addition to the clinical features of the underlying disease, the patient may present with a pathological fracture, and x-rays show a translucent area or areas. These areas are said to respond to radiotherapy.

action of a tendon. The commonest site is the growing end of a long bone, especially around the knee. Occasionally an osteochondroma arises from the pelvis or scapula. If the lump is growing from the inner aspect of the pelvis, intrapelvic pressure may develop.

On examination, the lump is large, sessile, lobulated, attached to bone but not to skin or muscle, and is not tender.

X-RAY APPEARANCES

The tumour arises from within the medulla of the parent bone. It has a broad base, is large, lobulated and sessile. There is irregular calcification. The cartilage cap is invisible on x-ray and no clearly defined separation into cortex and medulla is seen.

TREATMENT

The tumour is excised because of the risk of malignancy. Excision may be technically difficult because of the anatomical site.

PROGNOSIS

It is thought that in 1–2 per cent of cases, the tumour becomes malignant in adult life. It is then chondrosarcomatous and becomes larger and more painful; the x-ray appearance changes, the outline becoming more fluffy.

"BENIGN" GIANT-CELL TUMOUR

PATHOLOGY

There are two theories of the origin of benign giant-cell tumour: (*a*) that it is a form of fibrous dysplasia, in which there is interference with the normal process of bone removal (by osteoclasts) and replacement (by osteoblasts); according to Stewart, the microscopy of fibrous dysplasia resembles that of a benign giant-cell tumour; (*b*) that it is a true spindle-cell tumour; this, the more modern view, is supported by Jaffe and Lichtenstein.

Microscopically, spindle cells are present, but the dominant feature is numerous giant cells each containing many nuclei.

Macroscopically, the tumour is large, and asymmetrically placed at the end of a long bone. It is reddish brown in colour, and oozes blood. Often it contains patches of fat. The surrounding cortex is thinned.

Spread is chiefly local, but the tumour becomes quite big. Some are more "aggressive" than others and a few may even become malignant.

CLINICAL FEATURES

The tumour usually occurs between the ages of 20 and 30 years, rarely between 15 and 40 years.

It is nearly always situated at the very end of a long bone. Possibly, however, it originates in the metaphysis but grows so rapidly through the growth disc that by

On examination, a large lump is seen and the skin overlying it may be shiny, with prominent veins which are well demonstrated by infra-red photography. The lump is large, tender, attached to bone and often to muscles. No definite edge can be felt. A rapidly growing tumour is warm and may pulsate.

X-RAY APPEARANCES

A combination of bone destruction and bone formation is seen. In the medulla, there is an area of rarefaction, sometimes with patchy sclerosis; the tumour has an *ill-defined junction with the rest of the shaft.* The cortex is somewhere perforated. The periosteum may show sunray spicules and Codman's triangle; these are not common but when they do occur are diagnostic.

DIFFERENTIAL DIAGNOSIS

A painful lump near the end of a long bone in a young person must be presumed to be a sarcoma until the contrary is proved, if necessary with the aid of biopsy. Other conditions which must be considered are as follows:

(*a*) Post-traumatic swellings such as callus and myositis ossificans, which may be differentiated on x-ray.

(*b*) *Infective conditions such as staphylococcal osteomyelitis, or syphilis of bone;* in every case a white cell count and Wassermann test are essential.

(*c*) Benign tumours which are characterized both clinically and on x-ray by a well defined edge. The chest should always be x-rayed to exclude secondary deposits, and if any doubt remains, a biopsy must be performed.

TREATMENT

Biopsy may be an essential preliminary to treatment. It enables the diagnosis to be established beyond doubt and the pathologist may be able to predict whether the tumour will be radiosensitive.

An Esmarch bandage is applied above the tumour but the limb is not exsanguinated. The tumour must be adequately exposed and a portion excised preferably from the junction of tumour and normal bone.

CONSERVATIVE — Occasional cures are reported after very high doses of irradiation (9,000r). These are best achieved by means of supervoltage apparatus.

OPERATIVE — Amputation well above the tumour is sometimes performed as soon as the diagnosis is established, providing there are no demonstrable metastases. The prospect of thus effecting a "cure" is remote. Some surgeons therefore postpone amputation until pain or fracture make the limb a nuisance, and then amputate through the site of election above the tumour.

Stanford Cade advises irradiation followed by amputation a few weeks later if in the meantime no distant metastases have appeared. The irradiation relieves symptoms in nearly every patient, and there is no evidence that the consequent postponement of amputation adversely affects the prognosis. Those patients in whom metastases become demonstrable during the period of irradiation may thus be spared the unnecessary mutilation of amputation.

MALIGNANT TUMOURS

The classification has already been given on page 60. All the primary bone tumours (except the relatively rare fibrosarcoma) are highly malignant and usually fatal. They occur in young people, are painful, and have no definite margin on x-ray.

OSTEOGENIC SARCOMA

"Osteogenic" means "arising from bone", not necessarily "producing bone".

PATHOLOGY

All osteogenic sarcomata are derived from primitive mesenchymal cells which are "pluripotential" and may develop into various types of cell.

The following pathological description is based upon that of Stanford Cade, who considers that all osteogenic sarcomata are variants of one tumour.

Three types of cell are seen.

(*a*) Primitive spindle cells with numerous mitoses, which are the characteristic tumour cells.

(*b*) Products of these primitive cells, which may be predominantly fibroblasts (when the tumour looks like a "fibrosarcoma"), chondroblasts (when the tumour looks like a "chondrosarcoma") or mucoid cells (when it looks like a "myxosarcoma"). But these are all variants of one tumour.

(*c*) Bone cells of the two main varieties, osteoblasts which lay down bone, and giant-cell osteoclasts which destroy bone.

The macroscopic appearance is enormously variable, but the tumour is a big one situated in the metaphysis. If bone destruction predominates, the tumour is very soft and vascular (osteolytic); if there is a fair amount of bone formation, it is more grey and gritty (osteoblastic).

The tumour extends within the medulla, destroying bone. Cortex is eroded and sooner or later perforated. The periosteum is not at first penetrated but is pushed away from the shaft. New bone may be laid down along the Haversian canals (sun-ray spicules) and at the angles of periosteal elevation (Codman's triangle). Eventually the periosteum is penetrated and soft tissues are then rapidly infiltrated. The tumour metastasizes (*a*) via the bloodstream, chiefly to the lungs but also to other bones, commonly the skull and femur; and (*b*) via the lymphatics, regional lymph nodes being sometimes involved.

CLINICAL FEATURES

The incidence of osteogenic sarcoma is highest between the ages of 10 and 20 years and thereafter falls rapidly. (An older group is considered on page 68.)

The commonest site is at the metaphysis of a long bone, especially around the knee.

A history of trauma is present in more than half the cases and this raises the problem of possible association between tumour and trauma. Apart from trauma, pain is the first symptom. It is constant, worse at night and gradually becomes severe. Sometimes the patient presents with a lump. A pathological fracture is rare.

DIFFERENTIAL DIAGNOSIS

A gumma may present a similar appearance, so that a fibrosarcoma should not be diagnosed unless the Wassermann reaction is negative.

A subperiosteal lipoma on x-ray is more translucent than a fibrosarcoma.

TREATMENT

The tumour tends to be radioresistant but occasionally proves radiosensitive. Wide local excision should be followed by a course of radiotherapy of high dosage. If the tumour is suitably placed, amputation is the best treatment.

EWING'S TUMOUR (RETICULOCYTOMA)

PATHOLOGY

There are two theories as to the origin of Ewing's tumour: (*a*) that it arises from reticulum cells lining the marrow spaces (Ewing); (*b*) that it is a secondary adrenal neuroblastoma (Willis). Certainly the microscopy of a secondary adrenal neuroblastoma is identical to that of a Ewing's tumour; nevertheless both theories may be correct because a few patients do survive after amputation.

Microscopically, sheets of small dark polyhedral cells with no regular arrangement and no ground substance are seen. Macroscopically, the tumour is lobulated and often fairly large. It may look grey (like brain), or red (like red-currant jelly) if haemorrhage has occurred into it.

Locally, spread is similar to that of osteogenic sarcoma. The periosteum appears to resist the tumour and lay down layers like an onion. Distal spread is (*a*) via the blood to the lungs and also often to other bones; (*b*) via the lymphatics.

CLINICAL FEATURES

The tumour occurs most commonly between the ages of 5 and 15 years, though occasionally it is seen in slightly older patients. A long bone is usually affected, especially the tibia. The tumour is situated anywhere except at the ends of the bone.

Pain and a limp are the chief presenting symptoms; the pain is throbbing, worse at night and often severe; a history of trauma is common. The patient is sometimes ill and may be pyrexial. The lump is warm, tender, has an ill-defined edge and is attached to bone and to soft tissues. The pain, swelling and pyrexia may all fluctuate from time to time.

X-RAY APPEARANCES

The medulla contains a rarefied area with an ill-defined margin. The cortex is often perforated at some point. The periosteum is visible and shows striations parallel to the shaft.

DIFFERENTIAL DIAGNOSIS

The condition may resemble staphylococcal osteomyelitis, both clinically and on

PROGNOSIS

Nearly all cases die. Different authors record 5-year survival rates of 5–10 per cent or sometimes even higher. Probably some of the survivors were not suffering from true osteogenic sarcomata.

OLDER BONE SARCOMATA

True osteogenic sarcoma is a tumour of young people arising in apparently normal bone. In older patients a similar tumour can arise as a result of malignant change in previously abnormal bone.

"SECONDARY CHONDROSARCOMA"

The term "secondary chondrosarcoma" is used when malignant metaplasia occurs in an osteochondroma or possibly in a long-bone chondroma. (The so-called primary chondrosarcoma is merely an osteogenic sarcoma in which cartilage cells predominate.) The tumour is grey, gritty, grows slowly, and only metastasizes late.

It occurs in people aged 35–55 years who complain of a long-standing ache or of the recent increase in size of a previously stationary lump.

Amputation carries a reasonable prospect of survival. Where it is impracticable, radiotherapy may be tried, and a few survivals have been reported.

SARCOMA IN PAGET'S DISEASE

Occasionally one of the diseased areas in Paget's osteitis deformans undergoes malignant change. The patient complains of swelling and pain and the process resembles that of ordinary osteogenic sarcoma. The prognosis is hopeless.

PERIOSTEAL FIBROSARCOMA

PATHOLOGY

This rare tumour does not arise from bone cells but from the fibrous layer of the periosteum. Microscopically, fibroblasts dominate the picture. The tumour, which is large, grey, firm, fibrous and encapsulated, spreads slowly, later eroding the cortex from without. Metastases occur late and are then chiefly to the lungs.

CLINICAL FEATURES

The tumour usually occurs in patients over the age of 30 years and may be anywhere in a long bone. The patient presents with an ache which has lasted for many months, or with a lump which is growing slowly larger.

On examination the lump feels like hard rubber, and is only slightly tender. It is attached to bone, but because of its rubbery feel, this attachment is not easy to establish.

X-RAY APPEARANCES

There is a large, translucent, soft-tissue swelling immediately outside the bone. The cortex may be eroded on its outer surface.

SOLITARY MYELOMA

Solitary myeloma also occurs. Clinically and radiologically there is only a single large tumour, and many years may elapse before metastasis takes place.

SECONDARY CARCINOMA OF BONE

PATHOLOGY

In two thirds of cases, secondary bone deposits arise from carcinoma of the breast or prostrate, because these are the most common primary tumours. In a further sixth of cases, the deposits arise from other carcinomas (of thyroid gland, kidney, bronchus, genitalia, bladder, gastrointestinal tract). In the remaining sixth, no primary tumour is found.

The macroscopic and microscopic appearances correspond to those of the primary tumour.

There are three possible routes whereby the deposit may travel from the primary tumour to the bone.

(*a*) Most bone secondaries arise from tissue whose veins do not drain via the portal system into the liver. The cells travel via the vena cava and heart to the lung (where carcinoma cells can always be found microscopically in cases of bone deposits). In the lung, clumps of cells multiply, then probably penetrate capillaries to enter the systemic circulation and so reach bone.

(*b*) There is also a direct connexion between the pelvic plexus of veins and the vertebral veins, which explains why pelvic primaries are especially liable to give deposits in the pelvic bones and spine.

(*c*) Tumours of the rectum and of some other epithelial tissues may invade bone directly.

The above theories fail to explain why the muscles, heart and spleen enjoy immunity from secondary deposits.

CLINICAL FEATURES

The patient is usually aged 50–70 years and secondary deposits are found chiefly where red bone marrow is plentiful, namely, in the trunk bones (vertebrae, skull, pelvis, ribs) and "root" bones (upper ends of the humerus and femur).

The primary tumour may be obvious, but is sometimes undetectable. There may be cachexia.

The secondary deposit usually presents either with local ache (backache, headache, "rheumatic" pains), or as a pathological fracture following trivial injury. Some deposits, however, are clinically silent, being revealed only by x-ray, and some which fail to show even on x-ray are only discovered at autopsy.

X-RAY APPEARANCES

OSTEOLYTIC DEPOSITS — These are much the commonest variety seen and 90 per cent of breast secondaries are of this type. One or more rare areas are seen in the

x-ray. A white cell count is necessary and sometimes only a biopsy can establish the diagnosis.

Syphilis should always be excluded by a Wassermann test.

TREATMENT

Ewing's tumour is highly radiosensitive and the local growth is usually sterilized. In a few cases which do not respond satisfactorily amputation may be necessary. Neither measure is likely to prevent metastasis.

PROGNOSIS

It is claimed that 10 per cent of patients survive 5 years.

MULTIPLE MYELOMA (PLASMACYTOMA)

PATHOLOGY

The tumours are said to arise from plasma cells of the bone marrow. The typical microscopic picture is of plasmacytes with a large eccentric nucleus containing a spoke-like arrangement of chromatin. The tumours are usually multiple from the start; they are small, and grey or purple in colour. They look like multiple secondaries, but no primary tumour is ever found.

CLINICAL FEATURES

Myelomatosis is not as rare as is commonly supposed, and usually occurs between the ages of 40 and 60 years. Deposits are found wherever red marrow occurs; that is, in the trunk bones, skull and "root" bones. The clinical features fall into four groups:

GENERAL — Loss of weight, anaemia, cachexia and emphysema are common.

SPINE — There is constant backache, sometimes root pains and occasionally paraplegia.

UROGENITAL SYSTEM — Chronic nephritis is common and Bence-Jones proteose is excreted in two-thirds of cases.

LUMPS — Lumps may be palpable, especially in ribs, sternum or skull.

X-RAY APPEARANCES

Multiple small areas of rarefaction are seen.

DIFFERENTIAL DIAGNOSIS

It is very difficult to exclude multiple secondary carcinomatous deposits where no primary tumour is discovered. Electrophoresis and plasma protein estimation may assist in diagnosis.

TREATMENT

Radiotherapy will relieve pain and other pressure effects from individual lesions. Temporary improvement may follow the administration of radioactive phosphorus, nitrogen mustards in association with oestrogens, stilbamidine and urethane.

PROGNOSIS

The patient usually dies within 3–4 years

CHAPTER 8

ANTERIOR POLIOMYELITIS

ANTERIOR POLIOMYELITIS is best considered in the following stages.

(1) *Minor illness* — The virus invades the body and produces a trivial illness of short duration.
(2) *Major illness* — After a few days of apparent good health, the major illness begins, the central nervous system being attacked. This stage may be subdivided into (*a*) preparalytic stage (meningitis); (*b*) paralytic stage (when nerve cells have been damaged).
(3) *Convalescence* — This, the recovery stage, may arbitrarily be said to last from the time when pain and spasm have disappeared up to a maximum of 2 years.
(4) *Definitive stage* — Any residual paralysis lasts for the rest of the patient's life.

OTHER PATTERNS — It must not be supposed that the disease always, or even usually, follows the classical succession of stages. Other patterns include the following.

(*a*) [illegible]
(*b*) [illegible]
(*c*) [illegible]

MINOR ILLNESS

PATHOLOGY

THE VIRUS — There are three main types of virus, causing identical disease. Each produces a specific antibody, so that a second attack is possible.

The virus is found in the stools and throat of patients and contacts. During an epidemic it can also be grown from sewage farms and from flies.

INVASION — Probably the main source of infection is contaminated food, so that people with infected stools who handle food without washing their hands play an important part in disseminating the disease.

Droplet infection also occurs from the throats of infected patients; this requires close contact.

SPREAD — The initial lesion is in the gut or pharynx where the virus multiplies in the mucosa. From the mucosa spread is mainly by the bloodstream (viraemia).

CLINICAL FEATURES

All ages are affected. One third of cases is said to occur below the age of 5 years, one third aged 5–15 years and one third over 15 years. The minor illness is said to be detectable in only 40 per cent of cases and is usually recognized only in retrospect.

There may be malaise, headache, irritability and pyrexia, but all these are often slight. With catarrh of the pharynx or gut, the patient complains of a mild sore throat or a little diarrhoea.

medulla. Later the cortex appears mottled and may be destroyed so that the bone collapses. There is little or no periosteal reaction.

OSTEOBLASTIC DEPOSITS — These are usually from prostatic tumours, probably because the cells contain much phosphatase (acid serum phosphatase is increased). A single vertebral body may look too dense. More often the pelvis shows mottled increase of density; and this latter must be distinguished from Paget's disease, in which the alkaline phosphatase (not the acid) is increased.

TREATMENT

Most patients with secondary deposits in bone can be made comfortable for a time. Drugs solely for the relief of pain are of great value, and otherwise intractable pain may be relieved by a surgical division of pain-carrying nerve fibres. Excision of a fungating primary tumour helps to make the patient more comfortable.

RADIOTHERAPY — This is especially valuable for isolated secondary deposits. Pain and other pressure effects (for example, paraplegia from a spinal deposit) may be relieved for several years.

CONTROL OF THE HORMONE ENVIRONMENT — This applies to tumours of the breast or prostate and may be effected by drugs or operations. These measures often relieve pain and may retard or temporarily arrest growth of the tumours.

For prostatic tumours stilboestrol is of great value. Castration occasionally helps.

For breast tumours, androgens are given in pre-menopausal patients and sometimes in those who have only recently passed the menopause. After that oestrogens are usually more helpful. Operative control of the hormone environment may be achieved by oophorectomy with adrenalectomy, or by hypophyseal ablation.

TREATMENT OF FRACTURES — Fractures through secondary deposits often unite with treatment. The fracture may be treated conservatively, but to prevent the patient from being bedridden for his few remaining months of life, internal fixation is often kinder. Radiotherapy and control of the hormone environment may still be required.

Suggestions for further reading

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PENETRATION — The virus spreads along the perivascular spaces to the region of the anterior horn cells. Then follows a period of "armed truce" between cells and virus (Sabin). After a few days the virus may be destroyed without cell damage, or extensive cell destruction may occur. If the cells are fatigued they are more ready victims. Fatigue may determine paralysis and can certainly increase its severity.

CELL DAMAGE — Cells which are destroyed undergo chromatolysis. The Nissl granules disappear and the nuclear fragments are phagocytosed so that the cell disappears in a few days. Its axon undergoes Wallerian degeneration. Less severely damaged cells may undergo chromatolysis but not phagocytosis, and the normal cell structure returns in 4–5 weeks.

The damaged cells may be in one of the following situations.

(*a*) In the hypothalamus and brain stem (giving bulbar palsy).
(*b*) In the cord.
  (i) Anterior horn cells are the chief victims, giving flaccid paralysis.
  (ii) Damage to antero-lateral horn cells may occur and may explain the trophic changes.
  (iii) It has also been alleged that cell damage may occur in the posterior root ganglia (possibly causing pain and spasm) and to the internuncial cells (possibly causing incoordination).

CLINICAL FEATURES

GENERAL — After the minor illness (if recognized), there is a pause of 3–10 days during which the patient is apparently fit. The major illness then comes on, often abruptly, with pyrexia, pain in the head, back or limbs, and irritability. Retention of urine or incontinence may occur.

MENINGEAL — Severe headache and neck pain are common, and often there is vomiting. There is also neck rigidity; in children neck movements must be examined very gently, lest guarding be mistaken for rigidity.

A lumbar puncture is only necessary in poliomyelitis when the diagnosis is in doubt. The cerebrospinal fluid shows raised pressure, increased protein and increase in cellular content, at first neutrophils, later lymphocytes.

In spite of the meningitis the mind remains unclouded and alert.

PARALYTIC — It is not to be supposed that paralysis is common, even after the major illness, and the modern view is that paralysis is an infrequent complication of a common disease. Paralysis, when it does occur, usually begins abruptly, from 1 to 5 days after the onset of the major illness. It may spread quickly for a few days, after which no further spread occurs.

Paralysis is often preceded by pain in the areas about to be affected, and paralysed muscles remain painful and tender for some weeks.

The patient is examined systematically for evidence of paralysis; this examination must be gentle and limited so as to avoid fatigue or pain.

Bulbar palsy (polioencephalitis) — This form of the disease is increasingly common. Mental clarity is usually retained. Any cranial nerve may be involved, so that eye palsies, nystagmus, ataxy or vertigo may occur.

The most important brain-stem paralysis, however, is of the swallowing muscles. The patient complains of dyspnoea and dysphagia; he has weak speech and a weak cough.

DIFFERENTIAL DIAGNOSIS

It is clinically impossible to differentiate this early stage of poliomyelitis from many other minor illnesses, though during an epidemic poliomyelitis may be suspected. Stool culture is positive, but the test takes too long to be of practical help in diagnosis.

TREATMENT

REST — During an epidemic it is wise to put any patient with a catarrhal upset to bed until the temperature has been normal for 24 hours, and to avoid undue activity for the next 10 days.

"ISOLATION" — This is not practicable in the absence of a definite diagnosis. Visitors and crowds should be avoided.

NOTES ON PROPHYLAXIS

ISOLATION — House-to-garden isolation for patients and contacts is an ideal. The patient should be barrier nursed and the stools disposed of as in enteric fever.

HYGIENE — A high standard of public hygiene (avoiding flies and keeping food covered) should be aimed at, and also of private hygiene (hand-washing).

AVOIDANCE OF TONSILLECTOMY — During the epidemic season it is foolish to expose a large raw area to infection. Poliomyelitis following tonsillectomy is often bulbar in type.

AVOIDANCE OF UNNECESSARY INJECTIONS — There is some evidence that certain injections predispose to poliomyelitis as well as determining the site of paralysis. (Combined diphtheria and whooping cough innoculations especially should be avoided during an epidemic)

PASSIVE IMMUNIZATION — *Gamma*-globulins from convalescent serum can confer some immunity, but it is only partial and lasts only a few weeks.

VACCINATION — All three types of virus are grown on tissue culture (monkey's kidney). The suspension is filtered and the filtrate inactivated by formalin for 14 days. The resulting vaccine is tested for effectiveness and safety. Two intramuscular injections are given at 4-week intervals. Many people consider that a third "booster" injection after 6 months prolongs and heightens immunity Vaccination reduces the risk of paralysis to about 20 per cent of the risk in unvaccinated people.

Risks of vaccination include allergic reactions (rare and not severe); provocation of poliomyelitis if the patient was already incubating it (nowadays disregarded); and inducing poliomyelitis by accidentally injecting live vaccine (which happened in the early clinical trials but not since that time)

MAJOR ILLNESS

PATHOLOGY

MENINGITIS — The virus reaches the central nervous system chiefly via the bloodstream. It multiplies in the central nervous system, giving rise to a meningitis with a lymphocytic response. (In monkeys the virus can travel up the olfactory fibres and similar direct involvement possibly occurs in humans after tonsillectomy.)

neurone paralysis and the tendon reflexes remain normal or may even be increased. Moreover, glandular enlargement is usual and emotional instability common. The cerebrospinal fluid and stools are normal and the paresis recovers completely but slowly.

TREATMENT

GENERAL — Isolation is essential. Not only must the patient be isolated but if possible house-to-garden isolation of contacts is advised. Barrier nursing and the efficient disposal of stools are equally important.

Rest must be *immediate, enforced* and *complete.* As soon as preparalytic poliomyelitis is suspected, not only is the patient confined to bed but, ideally, he should not feed himself or even turn the pages of a book (Ritchie Russell). At this stage, activity increases the severity of paralysis. Sedatives are, of course, necessary.

BULBAR PALSY — If the patient cannot swallow his mucus, postural drainage is used. The foot of the bed is raised and the patient turned on his face. His posture is changed from time to time. Suction may be essential. With bilateral paralysis of the laryngeal abductors, a tracheotomy may be necessary (*see also* below).

RESPIRATORY PARALYSIS — A tank respirator (iron lung) is the best method of treating a patient who needs mechanical help in breathing. The patient's body, but not his head, is enclosed in an airtight, coffin-like box, and the air pressure within the box alternately raised and lowered by means of a pump.

Note — If both the respiratory and swallowing muscles are paralysed, a tank respirator is highly dangerous and may drown the patient; nor is postural drainage adequate, for mechanical help is needed. The best method is a high tracheotomy, using a cuffed tube and intermittent positive pressure respiration (hand or pump controlled). This technique has been used for pure respiratory paralysis but if a tank respirator is available it is preferable.

PARALYSIS OF LIMBS AND TRUNK — Pain is often a prominent feature and requires analgesics.

Contrary to earlier teaching, failure to splint a paralysed muscle in its shortened position does not prevent its recovery. The patient should be rested on a flat bed with fracture boards covered by a rubber mattress. One pillow is usually sufficient, and no elaborate splints should be used. If the arms are paralysed they may be rested on pillows or suspended in Guthrie Smith slings. The wrist can be supported in a cock-up splint, and the [illegible] garter. The patient lies flat with the hips extended, [illegible] the knees from hyperextending. A board for the feet to rest on prevents foot drop. The emphasis is on rest in a natural position and on the avoidance of cumbersome splints.

To discourage the development of contractures, not only is the posture changed at frequent intervals (nurses as well as physiotherapists should be trained to do this) but affected limbs are twice a day moved passively through their full painless range. Such movements should not be forced and must never hurt the patient. If pain or spasm are readily provoked by movements, the affected limbs should be wrapped in hot moist packs once or twice a day, a method advocated by Sister Kenny.

NOTE — All the above treatment may be summarized thus: the patient must be kept

A throat rattle (easily detected with a stethoscope or throat microphone) is of great significance because, occurring in a conscious patient, it is diagnostic of paralysis of the swallowing muscles.

Respiratory paralysis — Paralysis of the diaphragm and intercostal muscles causes difficulty in breathing and air hunger. The patient's breathing is shallow and rapid so that he cannot, in a single breath, count up to 15. The accessory muscles may be in action.

Paralysis of the limbs and trunk — This is often associated with considerable pain.

An affected limb looks shiny; the skin and subcutaneous muscles feel thick and porky. Active movement is of course impossible in affected muscles and these are tender and resentful of rough handling or stretching. The muscles are sometimes said to be in "spasm", a much abused word in the vocabulary of poliomyelitis. Almost certainly the spasm is simply a reflex guarding, to prevent nerve roots from being stretched.

DIFFERENTIAL DIAGNOSIS

In its preparalytic stage, poliomyelitis must be distinguished from other causes of meningeal irritation. In the presence of paralysis, poliomyelitis must be distinguished from other causes of paralysis, with or without meningeal irritation.

MENINGITIS WITHOUT PARALYSIS

True meningitis — In bacterial meningitis (pyogenic or tuberculous) the patient is mentally dull (not alert as in poliomyelitis); the muscles are not tender, and the cerebrospinal fluid is characteristic.

Virus meningitis may be due not only to poliomyelitis but to Cocksackie viruses or to those of the ECHO (Enteric Cytopathogenic Human Orphan) group. Unlike poliomyelitis these conditions are often accompanied by skin rashes and lymph-node enlargement. Stool culture is negative and paralysis does not follow.

"*Pseudomeningitis*" — A painful stiff neck may occur with acute tonsillitis or any acute fever in a child. Other physical signs should reveal the diagnosis.

PARALYSIS WITHOUT MENINGITIS

True paralysis — This may occur in haematomyelia, infective polyneuritis, after diphtheria, in Landry's paralysis, or it may be mimicked in hysteria. Usually the cause is obvious. Often there are also sensory changes, and there is no meningitis.

"*Pseudoparalysis*" (*painful limb*) — In acute osteomyelitis or acute arthritis the limb may be too painful to move Tenderness is, however, acute; there is marked leucocytosis and no meningitis

PARALYSIS WITH MENINGITIS

Poliomyelitis — The combination of paralysis with meningitis is strongly suggestive of poliomyelitis

"*Pseudopoliomyelitis*" — The cause of epidemic myalgic encephalomyelitis (Royal Free Disease) is unknown but is probably a virus Outbreaks occur chiefly in closed populations. At first, as in poliomyelitis, there is headache, malaise, sore throat and occasionally gastrointestinal upset. A major illness follows, with considerable pain and paresis. Unlike poliomyelitis, however, the paresis fluctuates, there is no clear-cut lower motor

disproportionately greater than muscle paralysis, possibly because the blood-vessel walls are paralysed by damage to the antero-lateral horn cells.

TREATMENT

GENERAL — The patient is fit and should get up and about as soon as possible; if necessary with splints, with crutches or in a wheelchair, but up at all costs. However, the following points should be borne in mind.

(*a*) If respiration still needs assistance the process of weaning from a respirator may have to be slow.

(*b*) If there is unbalanced trunk paralysis the risk of scoliosis is high and it may quickly become severe; the patient is kept recumbent until muscle hypertrophy has occurred, or a back splint (very rarely a graft) controls the deformity.

PERSISTENT PARALYSIS — Paralysis does not by any means always demand splintage. Unbalanced paralysis, however, may need splintage to prevent the surviving muscles from shortening and producing fixed deformity; and balanced paralysis may require splintage to provide stability. Any splints employed should be removed at least twice a day while the affected joints are moved passively through their full range.

RECOVERING PARALYSIS — Treatment is concentrated on trying to hypertrophy muscles by a programme of graduated exercises. It is useless to treat totally paralysed muscles, and pointless to treat strong ones; the aim is to strengthen weak ones. Training should begin early and quickly become strenuous, for fatigue is now harmless. Vigorous exercises do not increase the extent of recovery but achieve it more rapidly. The patient is coaxed, cajoled, persuaded and even bullied into increasingly powerful activity, progressing as quickly as his mentality permits.

Once it is apparent that a particular muscle group will never achieve useful power, the physiotherapist may permit or even encourage trick movements, teaching muscles to assume unfamiliar functions.

TROPHIC CHANGES — Trophic changes are difficult or impossible to prevent, but can be minimized by "coddling" the limb. The limb must never be allowed to become cold. Warm socks, a warm bed and a warm room are all of value. Exercises in a warm pool are especially helpful; not only is the limb warm but the patient can take exercise feeling light in body and light in mind.

DEFINITIVE STAGE

PATHOLOGY

The dead nerve cells have been replaced by scar. Paralysis is permanent and the [illegible] relative shortening results.

CLINICAL FEATURES

The patient, except for his paralysis, is fit. Paralysis is lower motor neurone in type, the muscles being flaccid and tendon reflexes diminished or absent.

alone (isolated), *alive* (by artificial respiration if necessary) and *aerated* (with a clear airway); he should be *relieved* (of pain), *rested* (by intermittent splintage) and *relaxed* (by reducing "spasm").

CONVALESCENT STAGE

PATHOLOGY

Dead cells are converted to scar. Their axons degenerate and the muscles they supply are paralysed permanently. Because of the paralysis there is some oedema of muscles, later a slowly increasing interstitial fibrosis, and much later, deposition of fat.
Surviving cells recover rapidly and yet the clinical process of improvement is slow and gradual. Such slow improvement is probably largely due to hypertrophy of surviving nerve cells and unaffected muscle fibres. Slow recovery of muscle power may also be due to the acquisition of new pathways when the damaged cells are in the brain stem.

CLINICAL FEATURES

GENERAL — The patient is not ill. Arbitrarily this stage is said to last 2 years, after which further recovery is impossible.

PERSISTENT PARALYSIS — Weakness of muscles may present in one of three ways.

(*a*) As an isolated weakness, that is, inability to perform a particular movement.

(*b*) Where one muscle group is more severely involved than its opponent (unbalanced paralysis), deformity results; the stronger muscles overcome the weaker, and may in time lose their extensibility, so that the deformity becomes fixed.

Unbalanced paralysis is the most important cause of deformity. Other causes are coagulation of oedema fluid if a paralysed limb is uninterruptedly splinted, and, possibly, the contracture of fibrous tissue, capsule and fascia.

(*c*) Where the muscles controlling a joint are all equally weakened (a condition conveniently called "balanced paralysis") the joint becomes flail.

RECOVERING PARALYSIS — Recovery begins early and may progress rapidly or very slowly. To estimate recovery, the strength of muscle groups is charted at regular intervals; their strength is recorded thus

0	total paralysis
1	a flicker of movement
2	a definite movement, but not enough to act against gravity
3	strong enough to act against gravity
4	powerful but not normal
5	full power.

It is possible to arrive at an approximate estimate of final power by adding 2 to the strength at 4 weeks and 1 at 4 months (though muscles which are totally paralysed may remain so).

TROPHIC CHANGES — These appear during the recovery stage and are a source of great trouble to the patient. The limb becomes cold, blue and liable to chilblains. These trophic changes are usually thought to result from venous pooling, a sequel to the paralysis, and probably this is the true explanation; but sometimes trophic changes are

method; operative lengthening (by oblique osteotomy with traction) is difficult and dangerous because nerves and vessels are also being stretched.

Alternatively the longer leg may be shortened by epiphyseal arrest at the knee, or, rarely, by excision of part of the femur with Kuntscher nail fixation, but both these methods of shortening involve operating on the only good leg.

REGIONAL SURVEY OF TREATMENT

Each joint will be reviewed in turn, considering firstly unbalanced paralysis, where one of the groups of muscles controlling a joint is more severely involved than its opponent, and then balanced paralysis, where the muscles controlling a joint are all equally affected.

SHOULDER

Unbalanced paralysis — Weak adductors matter little, for once the limb has been abducted, gravity can bring it down again; thus no deformity and little disability result.

Abductor weakness, however, renders the limb almost useless. Moreover, the strong unopposed adductors, aided by gravity, lead to fixed adduction deformity which may require operative correction. Loss of ability to abduct may be overcome (*see* below).

Balanced paralysis — This results in a flail shoulder. The power of abducting to nearly 90 degrees can be restored by arthrodesing the joint; the scapular muscles then elevate the arm, and gravity allows it to adduct. The joint should be fixed in 70 degrees of abduction and 30 degrees in front of the coronal plane. Arthrodesis is useless unless the scapular muscles are strong enough, and pointless if the hand is too weak for useful action.

ELBOW

Unbalanced paralysis — Unbalanced paralysis matters, as a rule, only if the forearm flexors are paralysed, for gravity can replace the extensors. The exception is in the patient who has to use crutches, for which elbow extensors are necessary. Normally, however, if only the extensors are powerful, it is reasonable to reattach them so that they will act as flexors; even though the resulting power is unlikely to permit a weight to be lifted, it may be sufficient to lift the hand to useful positions.

Balanced paralysis — This leads to a flail elbow. Again it is flexion that matters most. An intact pectoralis major muscle can be disinserted and attached to the biceps muscle. Failing this, it is sometimes possible to advance the origin of the wrist flexors higher up the humerus. Even if there are no muscles to stabilize the joint it is better for the patient to wear a moulded splint, which holds the elbow bent at a useful angle, rather than to have the joint arthrodesed.

WRIST AND HAND

Unbalanced paralysis — Weak wrist flexors are not much of a handicap, for gravity opposes the extensors. But paralysed extensors in the presence of strong flexors leads to fixed flexion of the wrist, a poor position for function. The deformity can, to some extent, be prevented by splintage but once deformity has occurred the wrist flexors should be re-routed to act as extensors.

Balanced paralysis — Balanced paralysis of flexors and extensors causes a flail wrist, but

An affected limb may look blue, is wasted and often short and deformed. There are frequently extensive chilblains, and the skin is cold to the touch. When a badly paralysed limb is picked up, it has a peculiar "floppy" feel which, in the presence of normal skin sensation, is almost characteristic of poliomyelitis.

Some movements cannot be actively performed. Passive movement is possible but may be limited in certain directions because of fixed deformity.

PRINCIPLES OF TREATMENT

Further recovery is, by definition, impossible. The aim of treatment is to minimize the effects of paralysis, often by means of apparatus or surgery.

[illegible] hole; treatment of a limb should not be contem- [illegible] because of widespread paralysis.

[illegible] hole; no splint or operation should be employed *to improve the function of part of a limb unless the usefulness of the limb as a whole* is thereby increased. For example, reconstructive surgery of a hand may be a pointless luxury if the patient is unable to put the hand to its task because of a flail shoulder; surgery may improve a foot, but if the patient still needs a caliper to stabilize his knee, he may have gained nothing by it.

Finally, consider the individual part. The chief problems and possible methods of management are considered in outline below.

ISOLATED WEAKNESS — This often needs no treatment. Apparatus such as a toe-raising spring sometimes helps. Tendon transplants are sometimes useful, especially in the hand. The prerequisites for a successful tendon transplant are: (*a*) any fixed deformity should first have been corrected; (*b*) the transplant must possess sufficient power and excursion to perform its new task; (*c*) where possible it should be synergic with the muscle being replaced; (*d*) the new line of pull should be a direct one and routed as subcutaneously as possible; (*e*) the transplant should be sutured under tension and, where practicable, to bone.

DEFORMITY — This may sometimes be prevented or minimized by splintage and physiotherapy. Once deformity has occurred, it may be necessary to divide contracted structures, but no contracted tendon should be divided until the possibility of its transplantation has been considered, for it must of necessity belong to an unparalysed muscle.

FLAILNESS — This often requires treatment, for, in the leg, stability is essential for walking, and in the arm, fixation of proximal joints may be essential to utilize hand movements. External splintage (such as a caliper or moulded arm splint) is often the best. Arthrodesis is especially valuable in the foot and is often of value at the shoulder.

TROPHIC CHANGES — These may be minimized by wearing warm clothing and never letting the limb get cold. Occasionally, sympathectomy is useful, for instance to help in healing ulcerated chilblains. The limb becomes warmer after sympathectomy but the improvement in circulation rarely lasts more than three years.

SHORTENING — This is of significance only in the lower limb and then only if paralysis occurs before the age of 11 years.

A short leg may be lengthened by raising the shoe, which is almost invariably the best

Balanced paralysis — Balanced paralysis of the hip muscles leads to flailness. Flexion can be achieved by thrusting the trunk forwards in walking, so that gravity helps the lower limb forwards into a flexed position; but extension and abduction cannot be mimicked and when weight is taken on the limb a severe Trendelenburg dip occurs. No satisfactory treatment is known. A method sometimes used is to fit a caliper attached by a hinged bar to a pelvic band; and to incorporate an abduction lock in the bar. The apparatus is cumbersome and not very efficient. Arthrodesis of the hip does at least provide stability, but is technically difficult to achieve, and a stiff hip is a great nuisance if the knee muscles are also paralysed.

It is usually best to accept the disability or to minimize it by using a stick which replaces the stabilizing muscles.

KNEE

Unbalanced paralysis — Unbalanced paralysis of the knee flexors is not often disabling, for the straight leg can be lifted by flexing the hip while the quadriceps muscle contracts, and gravity flexes the knee as soon as the quadriceps is allowed to relax. Only rarely does a genu recurvatum develop and necessitate a caliper with a Jones's knee-brace.

Unbalanced extensor paralysis is more disabling. Not only is the knee unstable on standing or walking but a fixed flexion deformity may occur which makes it impossible to stabilize the knee. It is a little unfashionable to transpose the hamstrings to the quadriceps, but the operation is well worthwhile; not only are the deforming muscles divided, but sometimes the reinforced quadriceps muscle is strong enough to stabilize the knee without a caliper.

Balanced paralysis — Balanced paralysis of the knee flexors and extensors is common and results in flailness. The patient may be able to brace the knee straight with a hand in the trousers pocket while walking. The next simplest treatment is to provide a caliper, which should be hinged at the knee to prevent the straight leg from being a nuisance in buses; the hinge must have a simple locking device to prevent the caliper from buckling when the patient stands. Women sometimes prefer to dispense with the caliper and have the knee arthrodesed; the individual must weigh the inconvenience of a permanently stiff leg against the elegance of a well-stockinged one.

ANKLE

Unbalanced paralysis — Unbalanced paralysis at the ankle joint is mainly of importance when the dorsiflexors are weak. A toe-raising spring or back stop attached to a leg iron can prevent foot drop; but if the plantar flexors are strong enough and unopposed, they pull the foot into fixed equinus deformity. Slight equinus deformity does not matter, and may indeed be an advantage if the quadriceps muscle is weak. Severe equinus deformity may require elongation of the tendo achillis. It is often better, however, to perform Lambrinudi's operation.

The subtaloid and midtarsal joints are arthrodesed and a segment cut off the front of the talus so that with the talus in full equinus posi[illegible] slight equinus. The talus, being fully plantarflexed, is locke[illegible] not plantarflex further, so preventing foot drop; moreover, [illegible] are powerful, the effect of the equinus position is to help stabilize the knee during walking. Thus stability

the wrist is not totally flail unless the long finger muscles are also paralysed. A flail wrist may be stabilized by a cock-up splint or by arthrodesis. Operation, however, is not often indicated, for it should only be performed if the fingers function well enough to take advantage of the stability, and if the fingers do function well, the wrist usually has sufficient stability already.

Paralysis of thumb and fingers — This is a serious handicap but if sufficient unparalysed muscle is available, many reconstructive operations are possible.

For the vice action of the hand, finger flexors are required, preferably aided by wrist extensors. It is sometimes advisable to arthrodese the wrist and utilize any acting wrist muscles to reinforce finger flexion. It should be noted that the arthrodesis serves two purposes: it stabilizes the wrist, and it also "liberates" muscles which can be given more important tasks.

The pincer action of the hand demands a strong opponens pollicis muscle; if this muscle is paralysed a substitute can be provided by detaching the flexor sublimis tendon from one finger, winding the tendon round that of flexor carpi ulnaris (which acts as a pulley) and inserting the sublimis tendon into the distal end of the first metacarpal. Excellent opposition is obtained in this way.

TRUNK

Unbalanced paralysis — Unbalanced paralysis in which the muscles of one side of the back, belly or chest are stronger than those of the other side, leads to scoliosis. The scoliosis is liable to become severe, especially in children, because deformity overstretches the weak muscles and gravity helps the strong. Supporting jackets may help to minimize the deformity, and are sufficient treatment in adults. In children, however, the curve should be prevented from increasing by a support (such as a Milwaukee brace). When growth in the child's spine is complete, it may be advisable to fuse the affected area, which is often extensive

Balanced paralysis — This leads to a floppy trunk, but not to fixed deformity. External supports can provide reasonable stability; they are of greater benefit than with unbalanced paralysis, for in the latter, it is difficult to oppose a constant unilateral force.

HIP

Unbalanced paralysis — This is mainly of importance when the gluteal muscles and the tensor fascia lata muscle are paralysed. If the patient has been treated sitting up instead of lying flat, the unopposed hip flexors are liable to produce fixed flexion deformity. This deformity should be prevented by nursing the patient prone part of the time and so stretching the flexor muscles Once established, fixed flexion can be overcome by osteotomy, or by Soutter's operation, in which the muscles are slid subperiosteally downwards from the front half of the ilium

Unopposed action of the tensor fascia lata or of the gluteal muscles may lead to fixed abduction of the hip and pelvic obliquity The deformity may be corrected by Ober's operation (in which the fascia lata and iliotibial band are divided above the great trochanter), or by Yount's fasciotomy (in which the iliotibial band is divided above the lateral femoral condyle).

Occasionally, unbalanced paralysis of the abductors and extensors leads to dislocation of the hip.

Suggestions for further reading

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[illegible] for Inequality of Leg Lengths."
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[illegible] "An Outbreak of Encephalo-
[illegible] Ed. London; Edward Arnold.
[illegible] *ry of the Upper Extremity.*

of the knee, ankle and subtaloid joints can, under suitable conditions, be provided by one operation.

Strong ankle dorsiflexors with weak plantarflexors is not often disabling or deforming, because gravity assists plantarflexion. If, however, imbalance is gross, fixed calcaneus deformity (usually associated with cavus) develops and requires surgical correction. Elmslie's operation (1934) is satisfactory for this purpose.

The midtarsal and front half of the subtaloid joint are first arthrodesed with the foot fully dorsiflexed; at a second stage, the back half of the subtaloid joint is fused and a wedge excised to bring the foot plantigrade. At the same operation the weak tendo achillis is split in two, half being used as a tenodesis from tibia to os calcis and the other half being reinforced with any available tendons having sufficient power.

Balanced paralysis — Balanced paralysis of ankle muscles leads to a flail ankle only if the toe muscles are also weak. Stability is readily provided by a below-knee caliper with a toe-raising spring attached to the shoe. Frequently, because of other associated paralysis, Lambrinudi's operation (*see* above) proves to be the best procedure. Only rarely is it necessary to arthrodese the ankle in poliomyelitis.

SUBTALOID JOINT

Unbalanced paralysis — This may affect either the invertor or the evertor muscles. It is convenient to think of the foot as being pulled upon by two lateral reins; if either is weak the other overacts and deformity, either valgus or varus, results. It is important to balance the foot, and to balance it as early in the disease as possible, even during the convalescent stage. Balance may be achieved by a toe-raising spring attached to the shoe on the side of the weaker muscle group, by tendon transplant, the stronger muscle being detached and reinserted so that when the foot is dorsiflexed it is neither in valgus nor in varus; or by a subtaloid midtarsal arthrodesis, which is often necessary because of other associated paralysis.

Balanced paralysis — This causes a flail subtaloid joint which is unstable from side to side, especially on rough ground. Double irons can provide stability but often an arthrodesis is better. Any method may be used, a popular one being Dunn's triple arthrodesis in which the subtaloid and midtarsal joints are fused and the foot displaced backwards on the leg. Lambrinudi's operation is equally effective.

TOES

Unbalanced paralysis — Unbalanced paralysis of the muscles controlling the toes is of importance only when the long muscles overpower the short. The result is a bunching-up of the whole foot into claw foot and claw toes—deformities which soon become fixed. The metatarsalgia which inevitably results may be relieved by suitable padding, supports and footwear designed to distribute pressure evenly. Lambrinudi advised arthrodesing all the interphalangeal joints in the straight position, and reinserting the long extensor tendons into the metatarsal necks, an operation which is laborious but has good results.

Balanced paralysis — Balanced paralysis of both long and short toe muscles causes a weak foot but no deformity and usually no treatment is required.

Cerebellar lesions are presumed to account for the rare ataxic type of cerebral palsy and possibly for the still rarer rigid type.

SYMPTOMS

Often there is a history of difficult labour, prematurity or kernicterus.

Early symptoms include difficulty in sucking and swallowing, with dribbling at the mouth. The mother may notice that the baby is stiff or wriggles awkwardly in an uncoordinated fashion.

Later it is noticed that the milestones are delayed. (A normal child usually holds up its head at 3 months, sits up at 6 months and starts walking at about 1 year.) Later still, the classical picture associated with cerebral palsy is encountered.

SIGNS

MENTAL — Mentality is often impaired, but not as often as was formerly supposed. Accurate assessment is important, for severe mental defect precludes useful treatment. The intelligence quotient is often assessed too low because the child looks odd, because his spasticity has hampered learning, and because of speech and hearing difficulties. The children are often emotionally unstable and may suffer from fits.

PHYSICAL — Four main varieties of cerebral palsy are recognized, but mixed types are not uncommon. There may also be defects of sight and hearing.

Spastic palsy — This type comprises about half the cases, though this figure used to be put higher. In nearly one-third of the cases the arm and leg on one side are affected (hemiplegia); in nearly one-third both legs are much more severely affected than the arms (diplegia); and in nearly one-third all four limbs are involved (quadriplegia). Monoplegia and triplegia are rare.

The facies is often characteristic, so that the children look like brothers and sisters. The limbs are held in deformed positions, as if the stronger mucles had overcome the weaker, so that typical deformities are adduction and internal rotation of the shoulder, flexion of the elbow, pronation of the forearm, flexion of the wrist, adduction of the thumb; flexion and adduction of the hips, flexion of the knee, equinus of the foot.

Skin sensation is usually normal.

The muscles feel rigid and resist stretching, and there is inability to relax. Tendon reflexes are increased and the plantar responses are extensor. Some muscles, however, may feel flaccid. Movements are clumsy and the gait is shuffling or scissors in type.

Athetosis — This type is commoner than was formerly supposed. Typically the limbs wave about with continual, irregular, wormlike movements which are purposeless. Usually the movements are uncontrollable, but sometimes the patient tries to keep the limb still by voluntarily contracting all the muscles of a particular joint. The condition may then be confused with the spastic type of cerebral palsy.

Often the face, tongue and speech muscles share in the athetoid movements and it is hard to resist incorrectly calling the children mental defectives.

Ataxia — This type is relatively rare. There is an irregular intention tremor and incoordination, but no spasticity, flaccidity or athetosis.

Rigidity — This is the rarest type. It was formerly confused with the spastic type, but the muscles are in a constant state of increased tone and, on examination, do not "give" like spastic muscles.

CHAPTER 9

CEREBRAL PALSY

CEREBRAL PALSY is more common and more important than formerly realized. The incidence is from 0·5 to 2 per 1,000 live births, so that the social problems are enormous. The term "cerebral palsy" is preferred to "spastic paralysis" because there is no true paralysis and the muscles are not necessarily spastic.

CAUSES

CONGENITAL — A true failure of brain development is a rare cause. Heredity plays no part.

TRAUMA — Gross trauma may damage the brain itself, or less severe trauma may affect the blood vessels. Though important, trauma is not nearly as common as was formerly thought.

ANOXIA — This may be due to perinatal difficulties.

KERNICTERUS — This may occur (*a*) because of Rhesus incompatibility (which can usually be prevented by adequate exchange transfusion) or (*b*) without Rhesus incompatibility; now thought to be associated with excess vitamin K used as a prophylactic against bleeding in premature infants

INFECTIONS — These may be either perinatal (for instance, toxoplasmosis) or occurring in early infancy (for instance, meningitis or encephalitis).

PATHOLOGY

At autopsy the brain may show atrophy of convolutions, evidence of old haemorrhages, or multiple small cysts (porencephaly) Groups of nerve cells are undeveloped, sclerosed or degenerate, and upon the site and extent of these lesions depends the clinical picture

Cortical lesions may impair mental development, and muscle control if the motor cortex is at fault

The old idea of a simple upper motor neurone lesion is not adequate. Probably destruction of Brodman's area 4 of the precentral cortex gives flaccid paralysis, while damage slightly further forwards (area 4s) affects fibres which synapse in the basal ganglia; their destruction leads to loss of the normal suppressor activity and consequently to increased stretch reflexes and muscle tone

Subcortical lesions involving the caudate and lenticulate nuclei remove the coordinating influences which are normally transmitted through the extrapyramidal tracts. Abnormal motor impulses, independent of voluntary activity, constantly stream along the undamaged neurones, giving athetosis.

At the hip — Internal rotation deformity may be treated by dividing the front half of the gluteus medius muscle (Durham's operation), or the gluteal nerve. Adduction deformity is usually treated by adductor tenotomy often combined with obturator neurectomy; but even if the hips are afterwards held abducted in plaster, deformity is liable to recur.

In the arm and hand — Fixed pronation of the forearm may be treated by resecting the insertion of the pronator teres muscle, or by transplanting flexor carpi ulnaris to extensor carpi radialis; but it should be remembered that the pronated position is often the most useful.

Flexion deformity at the wrist can be treated by arthrodesing the wrist in the position of function—a very valuable procedure. The wrist flexors are divided at the same operation.

Adduction deformity of the thumb is difficult to treat; tendon transplants rarely succeed, and probably the best operation is a bone graft fixing the first to the second metacarpal bone (bail graft).

Note — It should be remembered that immobilization in the corrected or overcorrected position must be maintained for many months after these procedures, and many surgeons advise night splints for months or years after the plaster is removed; otherwise the deformity is very liable to recur.

Suggestions for further reading

Baker, L. D. (1955). "Surgery in Cerebral Palsy." *Arch. phys. Med.*, 36, 88.
Neale, A. V. (1955) "Problems of Cerebral Palsy." *Post Grad. med. J.*, 31, 356.
Norman, R. M., Sandifer, P. H., Evans, E. S., and Tizard, J. P. M. (1953). "Discussion on Infantile Cerebral Palsies." *Proc. R. Soc. Med.*, 46, 627.
Phelps, W. M. (1957). "Long-term Results of Orthopaedic Surgery in Cerebral Palsy." [illegible]
Pollock, G. A [illegible]
Cerebral [illegible]
Woods, Grace [illegible]

TREATMENT

MENTAL TRAINING — It is important to try to decide as early as possible whether the child is educable, for if it is not, treatment is useless. But it is easy to underestimate mental ability; the child should be given the benefit of the doubt.

A quiet atmosphere, free from emotional strain, is helpful. Apart from ordinary education (in which specially designed furniture and toys are useful), speech therapy and occupational therapy play a large part. The earlier education is begun the better.

PHYSICAL TRAINING — There is no agreed technique of physical education. The aim is to teach new patterns of posture and movement. This is obviously easier if faulty habits, say, of walking, have not first to be unlearnt. Enthusiasm, gentleness and patience are the keynotes of success; when instructed, an intelligent mother with plenty of time is often the best physiotherapist.

SPLINTS — Temporary splints are often necessary to prevent deformity or to maintain a correction obtained by manipulation. Splints should be taken off daily and the joints put through their full range of movement. Heavily weighted boots may assist the child to walk.

DRUGS — On the whole, drug treatment has proved disappointing. Relaxants have been almost abandoned. The following drugs are claimed to have some value: primidone (for athetosis); meprobamate (for spasticity or athetosis); and alcohol injections into the corpus striatum.

OPERATIONS — The results of surgery are often disappointing, though operations have an established place in the treatment of spastic hemiplegia. They should not be performed too early; rarely below the age of 8 years, and certainly not until non-operative treatment has been given a fair trial. Nor should surgery be lightly undertaken in a patient with severe mental defect

In theory, the following types of operation are possible.

Operations on the brain — In recent years it has been claimed that hemispherectomy may abolish fits and temper tantrums without making paralysis any worse.

Operations on nerves — By dividing the motor fibres to an overacting muscle (Stoffel's operation) the muscle is weakened. This has been abandoned except for obturator neurectomy to paralyse the hip adductors.

Operations on tendons — Tendon transplants in the hand are theoretically attractive; in practice they fail because incoordination remains. In the foot, transplanting the tibialis anticus tendon from the inner to the outer side sometimes helps to overcome varus deformity.

Elongation or division of tendons is sometimes helpful for fixed deformity of the foot (equinus), elbow or hip.

Operations on joints — The wrist and foot are the joints which most frequently require arthrodesis.

REGIONAL SURVEY OF OPERATIONS — In practice, the commonest procedures are:

[illegible] required, and is [illegible] arus deformity [illegible] transplanting the tibialis anticus muscle to the outer side to prevent recurrence of the deformity.

Experimentally the axons grow at a speed of 4 mm. a day, but there is delay in starting, in crossing the gap, and in connecting with the end organ. In practice, the speed of recovery is 1–1·5 mm. a day.

OTHER STRUCTURES — Denervated muscles waste, and the joints they control are liable to become deformed and stiff. The skin and nails may undergo trophic changes. The brain may "forget" the pattern of muscle behaviour.

SYMPTOMS

There are no general symptoms. Local symptoms are numbness and weakness. With some partial lesions (particularly of the median nerve and the medial popliteal nerve) there may be pain and increased sweating (*see* Irritation Syndrome, page 94).

SIGNS

There are no general signs.

LOOK — There may be a scar of the causal wound. Anaesthetic skin looks smooth and shiny, the affected fingers are thin and tapering and their nails abnormal. Trophic ulcers may be present, especially in the foot. Muscle wasting is obvious and the attitude of a paralysed limb is characteristic.

FEEL — The anaesthetic skin feels smooth, cool and dry. A nerve bulb may be palpable and may be tender. Where sensory nerve damage exists, the patient himself will point to the anaesthetic areas; however, it is useful for the surgeon to map out the area of loss and to chart the quality of sensation in four grades, from total sensory loss up to 2-point discrimination.

MOVE — The patient cannot perform certain movements, though passive range may be full. Muscle tone and power are lost, and bulk diminished. In testing individual muscles, errors may occur, especially in the hand, because of anomalous innervation, trick movements, or supplementary movements. To assess recovery, power may usefully be charted in five grades (*see* page 78).

X-RAY — The bones may decalcify.

DIAGNOSIS

With a suspected nerve injury, the following questions arise:

Is a nerve lesion present? — A quick test for each nerve, in which a distal area of skin or a distally supplied muscle is examined, is useful.

At what level is the lesion? — Usually this is obvious from the injury; if it is not, individual muscles whose branches arise at successive levels must be tested. Special investigations are occasionally useful (*see* below).

What type of lesion is present? — Clinical examination may suggest a neurotmesis; a palpable neuroma confirms it. Partial division is liable to produce hyperaesthesia or excess sweating. With neurapraxia, paralysis is not total and recovery begins early. Special investigations may again be helpful.

Is the lesion recovering? — The muscle supplied nearest to and below the level of the lesion is tested.

CHAPTER 10

PERIPHERAL NERVE LESIONS

I: GENERAL CONSIDERATIONS

THE description which follows is largely based upon the work of the Peripheral Nerve Centres established during World War II.

CLASSIFICATION

The following classification was put forward by Seddon.

NEUROTMESIS (complete division) — The word "neurotmesis" means "nerve cutting". However, the term is applied not only to a nerve which has been cut across but also to one which is so severely scarred that it cannot regenerate spontaneously. Neurotmesis may be caused therefore by open wounds, traction injuries, compression, or intraneural injections.

AXONOTMESIS (incomplete division) — Axonotmesis is incomplete in the sense that only the axons are divided; the endoneural tubes are undamaged It occurs with closed fractures, dislocations and pressure injuries. Clinically it is at first indistinguishable from neurotmesis, but spontaneous recovery is likely.

NEURAPRAXIA (physiological division) — The axons are intact, the only lesion is degeneration of the myelin sheaths The larger motor fibres are mainly affected, the smaller sensory fibres less so; hence subjective tingling is common but sensory loss rare. Spontaneous recovery is the rule.

NOTE — Intermediate and mixed lesions also occur.

PATHOLOGY

THE NERVE — The space between the cut ends fills with blood clot, the clot organizes and Schwann cells from each stump grow into it. Distally, the axons degenerate and are removed by phagocytes The Schwann cells of the endoneural tubes multiply and, if the tube is not soon occupied by a growing axon, this multiplication narrows it.

Proximally, degeneration also occurs, but only for about 1 centimetre. Within a few days the cut axons proliferate and streams of axoplasm grow towards the gap. If obstructed by scar they form a bulky lump (neuroma). Otherwise they enter the Schwann tubes (not necessarily the correct ones) and grow along them The advancing axon is followed by advancing myelinization Eventually, the axon joins an end organ which enlarges unless it has in the meantime become too degenerate. The nerve fibre has "matured" when the myelinated axon is connected to an end organ.

Experimentally the axons grow at a speed of 4 mm. a day, but there is delay in starting, in crossing the gap, and in connecting with the end organ. In practice, the speed of recovery is 1–1·5 mm. a day.

OTHER STRUCTURES — Denervated muscles waste, and the joints they control are liable to become deformed and stiff. The skin and nails may undergo trophic changes. The brain may "forget" the pattern of muscle behaviour.

SYMPTOMS

There are no general symptoms. Local symptoms are numbness and weakness. With some partial lesions (particularly of the median nerve and the medial popliteal nerve) there may be pain and increased sweating (*see* Irritation Syndrome, page 94).

SIGNS

There are no general signs.

LOOK — *There may be a scar of the causal wound.* Anaesthetic skin looks smooth and shiny, the affected fingers are thin and tapering and their nails abnormal. Trophic ulcers may be present, especially in the foot. Muscle wasting is obvious and the attitude of a paralysed limb is characteristic.

FEEL — The anaesthetic skin feels smooth, cool and dry. A nerve bulb may be palpable and may be tender. Where sensory nerve damage exists, the patient himself will point to the anaesthetic areas; however, it is useful for the surgeon to map out the area of loss and to chart the quality of sensation in four grades, from total sensory loss up to 2-point discrimination.

MOVE — The patient cannot perform certain movements, though passive range may be full. Muscle tone and power are lost, and bulk diminished. In testing individual muscles, errors may occur, especially in the hand, because of anomalous innervation, trick movements, or supplementary movements. To assess recovery, power may usefully be charted in five grades (*see* page 78).

X-RAY — The bones may decalcify.

DIAGNOSIS

With a suspected nerve injury, the following questions arise:

Is a nerve lesion present? — A quick test for each nerve, in which a distal area of skin or a distally supplied muscle is examined, is useful.
At what level is the lesion? — Usually this is obvious from the injury; if it is not, individual muscles whose branches arise at successive levels must be tested. Special investigations are occasionally useful (*see* below).
What type of lesion is present? — Clinical examination may suggest a neurotmesis; a palpable neuroma confirms it. Partial division is liable to produce hyperaesthesia or excess sweating. With neurapraxia, paralysis is not total and recovery begins early. Special investigations may again be helpful.
Is the lesion recovering? — The muscle supplied nearest to and below the level of the lesion is tested.

SPECIAL INVESTIGATIONS WHICH MAY AID DIAGNOSIS

Nerve blocking — A small quantity of local anaesthetic may be injected into the injured nerve. If this is followed by greater sensory or motor loss the lesion is partial. Similarly, by injecting undamaged nerves, overlap can be diagnosed.

Electrical tests — Within a few weeks denervated muscle fails to respond normally to electrical stimuli, the anodal closing current eliciting a greater response than the cathode closing current. This "reaction of degeneration" has been largely abandoned as a method of testing nerves. In the rare instances that electrical reactions are helpful, a strength-duration curve may be plotted which shows if the lesion is partial or complete and if it is recovering. Electromyography is also capable of revealing the state of muscle innervation. These tests are elaborate and difficult; they rarely add to the information obtained by clinical examination.

TREATMENT

NERVE REPAIR — A divided nerve needs to be repaired. Difficulties arise in deciding whether the division is complete (neurotmesis) and in knowing when to operate. Nerve exploration with a view to repair is indicated when (*a*) the nerve is known to be divided because the lesion was seen at the wound toilet operation; (*b*) the nerve is presumed to be divided because recovery of the highest supplied muscle has not occurred in the calculated time, or because a palpable neuroma has developed; and (*c*) occasionally for diagnostic purposes.

It should be noted that some nerves, such as the brachial plexus and the posterior interosseus nerve, are hardly ever worth exploring, because they cannot be adequately sutured.

CARE OF PARALYSED PARTS — While recovery is awaited, the skin should be guarded against burns and the circulation assisted by massage. The joints should be moved through their full range twice daily to prevent stiffness. Splints may be necessary and "lively splints" are the best; they hold the paralysed muscle in its shortened position by means of a spring which is weak enough to allow the unparalysed muscles to work against it. Electrical stimulation of paralysed muscles may help to preserve their mobility and bulk, but is not as useful as was formerly thought.

SECONDARY OPERATION — Even if recovery of the nerve cannot occur, the function of the limb may be improved by splints or operations. For example, tendon transplants are useful for an irrecoverable radial nerve injury; in the foot, stabilization may be helpful; occasionally a high sciatic nerve lesion may necessitate below-knee amputation.

TIMING OF NERVE EXPLORATION

Not too soon — Primary suture is rarely satisfactory because of the following considerations.

(*a*) A wound toilet operation should not entail unnecessary stripping of tissue; therefore adequate nerve mobilization is unsafe.

(*b*) It is impossible at this early stage to judge how much of the nerve has been damaged and needs to be pared away.

(*c*) The sheath is too thin to suture properly and takes 3 weeks to thicken

Probably the only indication for primary suture is when a nerve has been accidentally divided during a clean operation.

Not too late — Excessive delay has the following disadvantages.

(*a*) The Schwann cells which bridge the gap and guide the growing axons attain their peak of activity at 3 weeks from injury; their activity then declines slowly.

(*b*) The Schwann tubes gradually become too narrow.

(*c*) The end-plates degenerate after a few months.

(*d*) The muscles atrophy and undergo interstitial fibrosis.

(*e*) The brain "forgets" how to work the muscles.

The ideal time — Nerve repair should be performed as soon as practicable after 3 weeks from injury. However, it may be necessary to postpone repair because the wound is unhealed. It may also be wise to postpone repair if the nature of the lesion is uncertain; with a closed fracture, for example, a nerve lesion often recovers spontaneously and it is worth waiting until the highest supplied muscle should have recovered.

Under no circumstances should more than a year elapse, for recovery after that time is unlikely; it is better to explore too soon even if the nerve is found intact.

TECHNIQUE OF OPERATION

Tourniquet — If a tourniquet is necessary it should be a pneumatic one and it must be released and bleeding stopped before the wound is closed.

Exposure — A long incision is essential, and the nerve must be widely exposed well above and below the lesion, before the lesion itself is cleared. The nerve must be handled gently with rubber loops or with non-toothed forceps holding only the sheath. To obtain adequate mobilization branches may be stripped up.

Resection — With complete division, the fibrous tissue of the proximal end is pared away with a razor blade until axons pout from the stump; similarly at the distal end until the empty tubes are seen. When the lesion is in continuity it is sometimes difficult to know whether resection is necessary or not; if the nerve looks and feels normal or only slightly thick, resection is not advised; if there is a soft fusiform neuroma resection is again inadvisable; if the neuroma is hard, it should be resected; a lateral neuroma usually needs resection.

Suture — The sheath only is sutured, using atraumatic needles with fine silk or wire. There must be no tension at the suture line, so that gaps must be bridged by mobilization of the nerve and, if necessary, transposition. (If acute flexion of a joint is required to bring the nerve ends together, then, however slowly the joint is subsequently mobilized, a traction lesion is likely, with consequent failure of recovery.) The sutured nerve is left in an intermuscular plane if possible.

Aftercare — After closure of the wound, the limb is splinted for 3–6 weeks to relieve the suture line from tension. Physiotherapy is then started and is designed to keep the skin, muscles and joints in good condition.

NERVE GRAFTS — In nerve repair there is a critical resection length above which it is useless to try to bridge a gap. The length varies from 7 to 10 cm. according to the individual nerve. With greater gaps, autogenous nerve grafts are possible and sometimes successful. If two major nerves (such as the ulnar and median nerves) are irreparable by suture, a piece of one (ulnar) may be used as a graft for the other (median). Alternatively, in certain areas, cutaneous nerves can be spared for use as grafts. These include the lateral cutaneous nerve of the thigh, the saphenous, the sural, and the medial

cutaneous nerves of the forearm. Because their diameter is small, several strips may be used (cable graft). Nerve grafts should always aim at being 15 per cent too long.

BONE SHORTENING — This is a theoretical possibility to bridge a large gap; it is permissible only when there is established non-union of a fracture, and then but rarely.

PROGNOSIS

The following factors influence prognosis.

TYPE OF LESION — Neurapraxia always recovers fully; axonotmesis usually recovers well; neurotmesis carries the worst prognosis.

LEVEL OF LESION — The higher the lesion the worse the prognosis.

TYPE OF NERVE — Purely motor or purely sensory nerves recover better than mixed nerves, because there is less likelihood of axonal confusion (axons growing towards the wrong kind of end plate).

SIZE OF GAP — Above the critical resection length suture is not successful.

DELAY IN SUTURE — This is a most important adverse factor. After a few months, recovery following suture becomes progressively less likely.

ASSOCIATED LESIONS — Damage to vessels, tendons and other structures make it more difficult to obtain satisfactory recovery of a useful limb even with nerve recovery.

IRRITATION SYNDROME

This occurs only with an incomplete division or with an apparently intact nerve; it does not follow complete division. Usually there has been a gunshot wound, often with sepsis. The median nerve and the medial popliteal nerve are most often affected.

There is spontaneous burning pain and the skin is markedly hyperaesthetic (if these are severe the condition is usually called causalgia). The skin is thin, shiny, warm and moist. Muscles are wasted and weak. In severe cases, if time and sedatives fail to bring relief, sympathectomy may help.

II: LESIONS OF INDIVIDUAL PERIPHERAL NERVES

BRACHIAL PLEXUS: BIRTH INJURIES

UPPER ARM TYPE (ERB'S PALSY)

CAUSE

A traction injury during difficult labour damages the plexus just proximal to Erb's point. The nerves involved are the fifth and sixth cervical nerves and sometimes the seventh is slightly affected

CLINICAL FEATURES

The mother notices that one arm is not being used. The abductors and external rotators of the shoulder and the forearm supinators are paralysed. The arm is therefore held to the side, internally rotated and pronated. If the condition remains untreated, contractures develop.

TREATMENT

The arm should be held abducted, externally rotated and supinated either on a splint or by tying the wrist behind the neck to the opposite axilla. Daily stretching and physiotherapy are necessary until the child uses the arm. Full recovery is usual.

If fixed deformities have been allowed to develop, they may require operative correction; for example, by osteotomy of the neck of the humerus for fixed internal rotation, or division of soft tissues for fixed adduction and pronation.

LOWER ARM TYPE (KLUMPKE)

CAUSE

This rare lesion follows breech delivery with the arm above the head. The nerves damaged are C.8 and Th.1, especially Th.1.

CLINICAL FEATURES

The intrinsic muscles of the hand and the finger flexors are paralysed. There may be some sensory loss in the ulnar forearm and hand and sometimes a Horner's syndrome.

TREATMENT

The fingers are kept supple in the hope of recovery, which is a slender one. Splints and operations are useless.

NOTE — There is also a whole-arm type of lesion, in which the entire plexus is torn and the limb flail.

BRACHIAL PLEXUS: LATER LESIONS

CAUSES

The commonest causes are gunshot wounds and motorcycle accidents, the latter causing traction which may avulse the roots.

Shoulder dislocations may give a partial paralysis, but it usually recovers.

Fractures of the clavicle rarely damage the plexus, and only do so if caused by a direct blow.

A cervical rib may compress the lower trunk.

CLINICAL FEATURES

In the whole-arm type, all the arm, forearm and hand muscles and some scapular muscles are paralysed. Most of the limb is numb. With injury at the level of the roots there is often a Horner's syndrome and sometimes associated cord damage; at the level of the trunks, the rhomboid muscles and serratus anterior muscle escape; and at the level of the cords the supraspinatus muscle escapes.

In the upper-arm type, the nerves involved are C.5 and C.6. As in Erb's palsy the shoulder abductors and external rotators and the forearm supinators are paralysed.

Sensory loss is over the deltoid muscle and the outer aspect of the arm and forearm.

The lower-arm type is rare. Wrist and finger flexors are weak, and the intrinsic hand muscles are paralysed so that a claw hand develops. Sensation is lost in the ulnar forearm and hand. There may be an associated Horner's syndrome.

TREATMENT

Suture is not possible in any brachial plexus lesion, because the nerves cannot be mobilized to bridge a gap without tension. Operation is only justified for diagnosis and prognosis and but seldom on these grounds.

The limb should be maintained in good condition because, with incomplete lesions, a useful amount of recovery sometimes occurs after 2–3 years.

When the lower trunk is not involved, the hand remains useful. It is then sometimes worthwhile to arthrodese the shoulder so that the arm can be abducted by the scapular muscles. Wrist and finger extension can be restored by means of a Robert Jones transplant.

MEDIAN NERVE

CAUSES

Gunshot wounds or fractures may give high lesions.

Cuts in front of the wrist may divide the nerve.

Dislocations of the carpal semilunar bone often cause temporary nerve compression.

Compression beneath the carpal tunnel is common and is described on page 144.

CLINICAL FEATURES

In low lesions the thenar eminence is wasted and the opponens pollicis muscle paralysed (this should be tested by feeling the muscle as contraction is attempted, because opposition can be faked by a trick movement). Sensation is lost over 3½ fingers, and this causes clumsiness, so that the patient cannot pick up a pin.

In high lesions the front of the forearm also is wasted; the thumb, index and middle finger flexors, the radial wrist flexor, and the forearm pronator muscles are all paralysed. Often the hand is held with the ulnar fingers flexed, the middle finger slightly flexed and the index straight (pointing index). Trophic changes are common.

TREATMENT

Suture should always be attempted in median nerve lesions. Extensive mobilization may be necessary; thus for lesions just above the wrist it may be necessary to extend the incision to above the elbow and to divide the bicipital fascia. Incomplete, but useful recovery is common.

While recovery is awaited the thumb should be held in the position of function.

If no recovery occurs the disability is severe because of sensory loss and loss of pincer action. If sensation recovers, but not opposition, a sublimis-opponens tendon transplant may help.

ULNAR NERVE

CAUSES

An open wound may injure the nerve at any level. Cuts with glass are common just above the wrist.

Closed fractures at the elbow, especially of the medial epicondyle, often cause damage, usually temporary.

Fracture of the lateral condyle, if un-united, leads to a cubitus valgus with delayed ulnar palsy; a mal-united supracondylar fracture may have the same effect.

Osteoarthritis of the elbow may cause ulnar palsy from friction neuritis.

A bilateral ulnar nerve lesion is rare in England, but in tropical countries it may accompany leprosy.

CLINICAL FEATURES

In low lesions (wrist) the hand is clawed, the ring and little fingers being hyperextended at the metacarpophalangeal joints and flexed at the interphalangeal joints. Wasting of the intrinsic muscles is especially obvious in the first cleft which, on being pinched, feels much too thin. The fifth finger cannot be abducted actively against resistance, nor the middle finger waggled sideways. Sensation is lost over the ulnar 1½ fingers.

In high lesions (elbow) although the hand is clawed the terminal interphalangeal joints of the two ulnar fingers are not flexed because half of the profundus muscle also is paralysed (loss of active flexion of the terminal joint of the fifth finger is a useful test). Otherwise sensory and motor loss is the same as in low lesions. In lesions well above the elbow, the flexor carpi ulnaris muscle also is paralysed.

TREATMENT

Exploration and suture of a divided ulnar nerve is well worthwhile and anterior transposition permits a gap to be bridged. Transposition is also advised when a deformed or degenerate elbow has caused the lesion; not only is the palsy prevented from advancing further, but some degree of recovery usually occurs. However, it has recently been shown that some lesions at the elbow are due to compression of the nerve by a fibrous band at the proximal end of the flexor carpi ulnaris muscle. Division of this band, without nerve transposition, is then usually sufficient (compare with the carpal tunnel).

While recovery is awaited, the skin should be guarded against burns. Lively splints keep the hand supple and useful.

If recovery does not occur, the hand still has reasonable function. Bunnell's operation (sublimis-extensor tendon transplant) is sometimes used to minimize clawing and strengthen the hand.

RADIAL NERVE

CAUSES

Open wounds may injure the nerve at any level.

At the elbow, fractures may cause damage which is usually temporary.

In the axilla a crutch palsy may occur; this always recovers.

Sensory loss is over the deltoid muscle and the outer aspect of the arm and forearm.

The lower-arm type is rare. Wrist and finger flexors are weak, and the intrinsic hand muscles are paralysed so that a claw hand develops. Sensation is lost in the ulnar forearm and hand. There may be an associated Horner's syndrome.

TREATMENT

Suture is not possible in any brachial plexus lesion, because the nerves cannot be mobilized to bridge a gap without tension. Operation is only justified for diagnosis and prognosis and but seldom on these grounds.

The limb should be maintained in good condition because, with incomplete lesions, a useful amount of recovery sometimes occurs after 2–3 years.

When the lower trunk is not involved, the hand remains useful. It is then sometimes worthwhile to arthrodese the shoulder so that the arm can be abducted by the scapular muscles. Wrist and finger extension can be restored by means of a Robert Jones transplant.

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While recovery is awaited the thumb should be held in the position of function.

If no recovery occurs the disability is severe because of sensory loss and loss of pincer action. If sensation recovers, but not opposition, a sublimis-opponens tendon transplant may help.

SCIATIC NERVE

CAUSE

Injury to the main sciatic nerve is rare except in gunshot wounds.

CLINICAL FEATURES

The calf and leg are thin and the patient walks with a drop foot; all muscles below the knee are paralysed. Because the quadriceps muscle is supplied by the anterior crural nerve it functions normally, but knee flexion is weak because the hamstring supply has been damaged. Sensation is absent below the knee (except on the medial side of the leg) and trophic ulcers often develop on the sole.

TREATMENT

Suture should be performed if possible.

While recovery is awaited, below-knee irons and a toe-raising spring are worn. Great care is taken with socks, shoes and foot toilet to try to avoid trophic ulcers.

If recovery fails and sores develop, a below-knee amputation may be necessary.

ROOT COMPRESSION

The commonest cause of pain along the distribution of the sciatic nerve is root compression by a prolapsed intervertebral disc (*see* page 178).

LATERAL POPLITEAL NERVE

CAUSES

The main nerve may be damaged at the level of the neck of the fibula by traction injuries when the knee is forced into gross varus position, by pressure from a splint, from lying with the leg externally rotated, or by wounds.

The musculocutaneous and anterior tibial branches are rarely injured except by gunshot wounds.

CLINICAL FEATURES

With a high lesion (the main lateral popliteal nerve), the outer side of the leg is wasted and the patient cannot dorsiflex or evert the foot and toes. He has a foot drop and therefore walks with a high stepping gait. Sensation is lost over the front and outer half of the leg and the dorsum of the foot and toes.

A low lesion involving only the musculocutaneous branch causes paralysis of the peroneal muscles with wasting; on dorsiflexion the foot is pulled into varus. Sensation is lost over the outer side of the leg, foot and toes.

A lesion involving only the anterior tibial branch causes paralysis of the tibialis anticus muscle and the long toe extensors. The front of the leg is wasted and the patient cannot dorsiflex his foot without everting it. Sensation is lost only in the first cleft.

CLINICAL FEATURES

In low lesions (posterior interosseus nerve) the posterior forearm looks flat and the patient can neither extend the interphalangeal joint of the thumb nor the metacarpophalangeal joints of the fingers and thumb. There is no detectable sensory loss.

In high lesions (around the elbow) the radial wrist extensors and the supinator muscle also are paralysed (the patient can still supinate the flexed elbow with his biceps muscle).

In very high lesions (axilla) the triceps muscle also may be paralysed. There is a small area of sensory loss on the dorsum of the first cleft.

TREATMENT

Suture below the elbow is rarely possible, because the nerve cannot be sufficiently mobilized. At or above the elbow suture may be worthwhile.

While recovery is awaited, a Brian Thomas splint is worn; this is a "lively" splint holding the metacarpophalangeal joints straight and the thumb straight and abducted, while still permitting active use of the hand.

If recovery does not occur, the disability can be almost completely overcome by tendon transplants, of which the commonest is the Robert Jones transplant: the pronator teres tendon is transplanted to the radial extensors of the wrist; the palmaris longus tendon to extensor pollicis longus; the flexor carpi radialis tendon to the short extensor and long abductor of the thumb; the flexor carpi ulnaris tendon to the finger extensors and possibly to the long thumb extensor.

NOTE — Tourniquet palsy is more common in the upper than in the lower limb. It usually affects only or predominantly the motor fibres. Spontaneous recovery is usual.

LUMBOSACRAL PLEXUS

The plexus as a whole is not liable to injury.

Individual roots may be compressed by an extradural tumour or a prolapsed intervertebral disc.

Pressure on L 5 root may cause weak gluteal muscles, weak foot dorsiflexors and altered sensation over the front of the leg and dorsum of the foot.

Pressure on S.1 root may cause weak gluteal muscles, weak foot plantarflexors and altered sensation along the sole of the foot.

Individual nerves (other than the sciatic) may be affected.

The lateral cutaneous nerve (L 2 and 3) may be compressed within fibres of the inguinal ligament, causing local tenderness and hyperaesthesia or numbness over the outer thigh. This is known as meralgia paraesthetica and is an example of a tunnel syndrome. If severe, the condition may be relieved by freeing the nerve or if necessary dividing it

The anterior crural nerve (L.2, 3, 4) may be injured by a gunshot wound. This is rarely seen, because associated femoral artery damage often proves fatal. There is quadriceps paralysis and numbness of the anterior thigh and medial aspect of the leg.

CHAPTER 11

FUNDAMENTALS OF ORTHOPAEDIC OPERATIONS

I: ARTHROPLASTY AND ARTHRODESIS

ARTHROPLASTY is the surgical refashioning of a damaged joint. Arthrodesis is the total abolition of movement by surgical means. Formerly the term "excision" was used when part or all of the tissues of a joint were removed, whether the aim was increased range or ankylosis.

The joints most often needing arthroplasty are the hip (for osteoarthritis or ankylosing spondylitis) and the metatarsophalangeal joint of the hallux (for rigidus or valgus deformity).

The joints most often needing arthrodesis are the hip (for osteoarthritis or tuberculosis); the knee (for tuberculosis); the shoulder (for abductor paralysis or tuberculosis); the subtaloid and midtarsal joints (for poliomyelitis); and the toe joints (for hammer toe).

It should be clearly understood that neither operation is indicated unless symptoms are sufficiently severe and are not relieved by less drastic means.

INDICATIONS

ARTHROPLASTY

Indications for arthroplasty are *pain*, especially if combined with stiffness; *stiffness*, especially bilateral stiffness of the hips, temporomandibular joints or elbows (as from ankylosing spondylitis or rheumatoid arthritis); and *deformity*, especially combined with stiffness.

ARTHRODESIS

Indications for arthrodesis are *pain* (which may be due to osteoarthritis); *deformity*, (which may be due to any chronic arthritis); *unsoundness* (as after tuberculous arthritis); and *instability* (as after poliomyelitis, especially at the tarsus, shoulder and wrist).

ARTHRODESIS VERSUS ARTHROPLASTY

Although the objects of the two operations appear diametrically opposed, their indications overlap. Consider for example an osteoarthritic hip which may be painful, stiffish and deformed: successful arthrodesis will certainly abolish pain and the stiffness is little or no disability providing it is amply compensated by free mobility

TREATMENT

Where possible the nerve is sutured.

While recovery is awaited a toe-raising spring may be worn if necessary, and the skin must be guarded against ulceration.

If recovery does not occur, any disability can be minimized by tendon transplants or foot stabilization.

MEDIAL POPLITEAL NERVE

CAUSE

The nerve is rarely injured except in open wounds.

CLINICAL FEATURES

With a complete lesion of the main medial popliteal nerve, the calf is thin and the heel valgus. The patient cannot plantarflex his ankle. The intrinsic muscles of the foot are paralysed so that the toes are clawed. Sensation is absent over the sole (where there may be a trophic ulcer) and part of the calf.

A lesion of the posterior tibial branch alone causes much less wasting of the calf and weakness of plantarflexion. The toes are clawed from intrinsic muscle paralysis. Sensation is lost over the sole of the foot, but the sural supply remains.

Unlike the lateral popliteal nerve, the medial popliteal or the posterior tibial nerve may suffer from the irritation syndrome, especially when incomplete division is associated with sepsis. There is considerable pain, the skin is warm, wet and shiny and the joints are stiff.

TREATMENT

A complete lesion should be sutured if possible.

While recovery of a high lesion is awaited, a side-iron is worn which fits into a square socket in the heel of the shoe; this prevents the foot dorsiflexing too far. A lesion confined to the posterior tibial branch needs no splintage. Care is taken to avoid ulcers on the sole.

Occasionally an irritation syndrome is so severe as to warrant below-knee amputation.

Suggestions for further reading

Barnes, R (1949) "Traction Injuries of the Brachial Plexus in Adults" J. Bone Jt Surg., 31B, 10.

— In *Modern Trends in Orthopaedics* ... don, Butterworth

Broc ... the Brachial Plexus." *J. Bone Jt Surg.*, 31B, 17.

— (1955). "The place of Nerve Grafting in Orthopaedic Surgery." *Ibid.*, 37A, 299.

Mayfield, F. H. (1951) *Causalgia.* Oxford; Blackwell

Seddon, H J (1954) "Peripheral Nerve Injuries" *Spec Rep. Ser. med Res. Coun* No 282. London, H M Stationery Office.

FINGERS — 20 degrees of flexion.

HIP — 10 degrees flexion (to permit sitting), 10 degrees abduction (more if there is shortening) and 10 degrees external rotation.

KNEE — 180 degrees (*occasionally at 170 degrees so that the leg sticks out less in a 'bus*).

ANKLE — 90 degrees (slight equinus for women who wear higher heels).

SUB-TALOID — Neutral (neither varus nor valgus).

TOES — 180 degrees.

REGIONAL SURVEY OF ARTHRODESIS AND ARTHROPLASTY

SHOULDER — Arthroplasty is not advised.

Arthrodesis may be necessary for paralysis of the abductor muscles. The joint surfaces are denuded of cartilage and fixed by a screw. The shoulder is held in plaster in the optimum position.

For the aftermath of tuberculosis, an extra-articular arthrodesis is preferred; the outer clavicle and acromion are osteotomized and hinged into a bed chiselled out of the head of the humerus. The shoulder is held in plaster for 3–6 months; surprisingly enough this method is usually successful.

ELBOW — Arthroplasty should be performed only if both elbows are stiff, which sometimes occurs in rheumatoid arthritis or ankylosing spondylitis. Only one elbow is operated upon. The bone ends are excised and the resulting long fibrous joint, though weak, can be placed by the other hand in any desired position. Arthrodesis is hardly ever required because an unsound elbow is sufficiently protected by a sling or polythene splint.

WRIST — Arthroplasty is not advised.

Arthrodesis may be required for painful osteoarthritis or for paralysis. Through a posterior incision articular cartilage is removed from the proximal row of the carpus and from the lower radius. A strong bone graft is slotted into a trough extending from the radius to the second and third metacarpals. The joint is packed with cancellous chips, and the wrist held dorsiflexed in plaster.

THUMB — Arthroplasty of the carpometacarpal joint is easily achieved by excising the trapezium It is performed only for painful osteoarthritis.

Arthrodesis is often preferred. Articular cartilage is excised and the bones fixed together with a screw or bone graft.

FINGERS — Arthroplasty is not advised.

Arthrodesis of the terminal interphalangeal joint may be required for flailness due to a cut profundus tendon. Cartilage is removed and the joint held by a screw or wire in 20 degrees of flexion.

SPINE — Arthroplasty is neither desirable nor possible.

Arthrodesis is often performed for tuberculosis, for degeneration of the intervertebral joints or to stabilize the correction of a scoliosis. In Albee's technique the spinous processes are split longitudinally and grafts inserted. In Hibbs' method the laminae and processes are rawed and the intervertebral joints thoroughly excised; flaps of bone are turned alternately upwards and downwards from the laminae and interleaved to form

of the back, the opposite hip and the same knee; an arthroplasty is less certain to relieve pain and less likely to be stable, but it makes fewer demands on the compensating joints and is therefore indicated if they lack free mobility.

Similar considerations apply to disorders of the metatarsophalangeal joint of the hallux (valgus and rigidus): arthrodesis abolishes pain and can overcome deformity but, unless the interphalangeal joint has a very full range of movement, the patient will be unable to vary the height of her heel; arthroplasty (such as Mayo's or Keller's operation) should also abolish pain and overcome deformity but usually the foot loses a little power.

TECHNIQUE

ARTHROPLASTY

(1) A gap is created by refashioning the bone ends. This may necessitate cutting off one bone end (as in Keller's operation) or cutting the surface of both bone ends (as in operations at the hip).

(2) The raw surfaces must be prevented from joining together. This may be achieved in three ways.

(*a*) A non-absorbable barrier is interposed between the bone ends (interposition arthroplasty—a Smith-Petersen cup may be used).

(*b*) A large gap is left between the two ends (gap arthroplasty; for example, Girdlestone's operation at the hip).

(*c*) A bone end may be replaced by a prosthesis (replacement arthroplasty; for example, Moore's operation at the hip).

(3) Function must be regained. This is often a long and arduous process, for the muscles may be wasted because of the underlying disease, or they may be damaged by the operation.

ARTHRODESIS

(1) The joint surfaces are denuded of articular cartilage; preliminary dislocation is therefore usually necessary. At the hip and shoulder an extra-articular arthrodesis is preferred when the operation is for the aftermath of tuberculosis; dislocation and denudation are omitted to lessen the danger of reactivating the disease.

(2) The bone ends are trimmed until they fit together in the optimum position. Any dead space is packed with bone chips.

(3) The joint is held in the optimum position (*see* below) until the bone ends have united. Often internal fixation is required, using bone grafts, screws, or compression clamps. In addition, external fixation by plaster is nearly always necessary. At the hip, special problems arise, and these are discussed on page 205.

The optimum positions for arthrodesis (and ankylosis) are as follows.

SHOULDER — 70 degrees abduction, 30 degrees in front of the coronal plane and rotated so that the hand may reach the mouth.

ELBOW — 90 degrees flexion for a clerk, 160 degrees for a labourer. The radio-ulnar joint may be in the mid-position or more pronated for writing

WRIST — 15 degrees of dorsiflexion.

II: OSTEOTOMY

INDICATIONS

DEFORMITY ALONE — Many deformities are ugly enough to warrant osteotomy. Examples are bow legs, relapsed club foot, valgus elbow. It may also be worthwhile osteotomizing a deformed bone to prevent subsequent osteoarthritis.

DEFORMITY WITH PAIN — In osteoarthritis of the hip, a displacement osteotomy reduces deformity and often relieves pain. Similarly an unsound deformed hip following tuberculosis benefits from osteotomy. In Paget's disease straightening a painful bent bone may relieve pain.

INSTABILITY — Instability of the hip due to an unreduced congenital dislocation or an ununited transcervical fracture may be helped by osteotomy.

TECHNIQUE

There are three essential stages of the operation:

(1) BONE DIVISION — This should be performed as near as possible to the site of deformity. The bone may be divided transversely or obliquely according to the deformity which is to be corrected. It may be useful to divide only seven-eighths of the bone circumference with a chisel or saw and to break the remaining eighth by hand. Sometimes bone is divided in two places and the wedge between is excised; if so, the base of the wedge is on the convex side of the deformity.

(2) CORRECTION OF DEFORMITY — It may be necessary to shift one fragment, to twist it, to tilt it, or to combine these movements. The aim is to obtain a complete correction, because deformity is more liable to recur if correction is only partial. The cut surfaces should be in close apposition when correction is complete.

(3) SPLINTAGE — If large areas of bone are in contact, fixation by plaster is usually sufficient. Often, however, internal fixation is used in addition to plaster. The correction must be held until the bone ends are completely united. Even when the plaster has been removed, a careful watch must be kept for recurrence of the deformity.

REGIONAL SURVEY OF OSTEOTOMIES

UPPER HUMERUS — Occasionally osteotomy is required if the shoulder has become fixed in adduction or internal rotation because of disease or unbalanced paralysis.

LOWER HUMERUS — Varus deformity at the elbow from mal-union of a supracondylar fracture may be corrected by removing a wedge of bone from the outer side of the humerus just above the elbow (the radial nerve must be identified and avoided).

UPPER RADIUS — Osteotomy may, very occasionally, be required for radio-ulnar synostosis (congenital or post-traumatic).

LOWER RADIUS — Malunion of a Colles' fracture may rarely require corrective osteotomy.

METACARPALS — Osteotomy for malunion is hardly ever necessary.

SPINE — In ankylosing spondylitis severe kyphosis may be associated with stiffness of the lumbar and cervical spine, so that the patient may be unable to see in front of him.

a continuous bridge. Many surgeons raw the laminae and processes and (with or without excising intervertebral joints) apply bone grafts taken from the ilium or tibia. In addition, strong cortical grafts may be placed on each side of the spinous processes and screwed together through these processes.

HIP — Arthroplasty is indicated in painful osteoarthritis if there is also limited movement in the other hip, the same knee or the lumbar spine. The femoral head is reshaped, the acetabulum deepened and a metal barrier (Smith-Petersen cup) interposed; alternatively, if the head needs extensive reshaping it may be replaced by a metal prosthesis.

Arthrodesis is indicated in osteoarthritis when the "compensating" joints are mobile. It is not easy to achieve but gives excellent results. Articular cartilage is removed and the joint fixed by a long trifin nail. A plaster spica is necessary for several months and must include the knee, unless the Pyrford technique is employed; in this technique, after the surfaces have been rawed and a long nail inserted, subtrochanteric osteotomy is performed and skeletal traction maintained for 6 weeks, at the end of which time a short plaster spica is sufficient. In Brittain's extra-articular arthrodesis (for tuberculosis) an osteotomy is combined with an ischiofemoral graft.

KNEE — Arthroplasty is not satisfactory and gives an unstable joint (though patellectomy for patellofemoral osteoarthritis may be considered an arthroplasty and is useful).

Arthrodesis is indicated after tuberculosis or for severe osteoarthritis. The patella, synovium and diseased tissues are excised (if the operation is for tuberculosis) and the bone ends sawn across. They are held together with the knee straight by parallel Steinmann pins inserted in the femur and tibia. The pins are connected at their outer ends by compression clamps (Charnley's technique).

ANKLE — Arthroplasty is neither desirable nor satisfactory.

Arthrodesis may be required for old tuberculosis, for osteoarthritis or for instability. The joint is exposed and rawed. It may then be held by compression clamps, or by a tibial graft inserted into a socket in the talus, or by using the lower fibula as an onlay graft and screwing it to tibia and talus.

SUBTALOID — Arthroplasty is not practicable.

Arthrodesis of the subtaloid and midtarsal joints is used for degenerative changes following inflammation, injury, or most often, to stabilize a paralysed foot. The joints are exposed from the outer side, dislocated, rawed and replaced in the plantigrade position (if the operation is for paralytic drop foot, the talus is sometimes left in the equinus position, and the midtarsal joint dorsiflexed).

HALLUX — Arthroplasty of the metatarsophalangeal joint is commonly performed for painful hallux valgus and sometimes for hallux rigidus. The head of the metatarsal may be excised (Mayo) or the proximal half of the proximal phalanx (Keller).

Arthrodesis is occasionally used for the same conditions if the interphalangeal joint is sufficiently hypermobile. The metatarsophalangeal joint is rawed and fixed by a wire, screw or clamps.

OTHER TOES — Arthroplasty is not required to restore movement, but a painful metatarsal head may need excision. Arthrodesis is often necessary for hammer toes or for claw toes. Cartilage and bone are removed until the bone ends fit together with the toe straight. It is then held by a collodion splint or wire.

SLIPPED EPIPHYSIS — If epiphyseal displacement cannot be corrected by traction or very gentle manipulation, some surgeons advise open correction at the epiphysis itself or through the neck. This is dangerous and often leads to avascular necrosis.

A safer method is to remove a subtrochanteric wedge of bone and to close the resulting gap by abducting the femoral shaft. To correct external rotation deformity the shaft is also rotated inwards. The limb is held abducted in plaster until the osteotomy has united. When the plaster is removed, the patient adducts the affected leg to bring it parallel with the normal leg. Because the osteotomy is united, movement occurs only at the hip joint. The effect is to make the epiphyseal line more horizontal, thereby preventing further slipping.

In the healed stage after a slipped epiphysis, mal-union may be corrected by a similar osteotomy, thus reducing the risk of osteoarthritis.

FRACTURE — An un-united transcervical fracture may be treated by McMurray's osteotomy. The shaft is divided obliquely from below the great trochanter to above the lesser. It is shifted inwards and held abducted. As with the wedge osteotomy for slipped epiphysis, when the osteotomy has joined and the patient adducts his leg, the fracture-line becomes more horizontal, and union more likely. Even if union fails to occur, the inward shift aids stability.

OSTEOARTHRITIS — Subtrochanteric osteotomy is again used, and the shaft may be shifted inwards. By holding the shaft abducted there is apparent increase of length. Not only is deformity corrected but pain is often relieved. To avoid knee stiffness, internal fixation is preferred to plaster.

ARTHRODESIS — When the Pyrford technique is used, the hip is fixed internally in its deformed position, and deformity is corrected by a subtrochanteric osteotomy. The patient is then treated on tibial traction for 6 weeks. Not only is it easy to prevent the knee from stiffening, but any movement in the upper femur takes place at the osteotomy (where union always occurs) rather than at the hip joint (where union is difficult to achieve). The joint itself is therefore held more efficiently. After 6 weeks the patient is allowed up in a short hip spica.

III: BONE GRAFTS

VARIETIES

AUTOGENOUS

(*From the patient himself*)

The a[illegible] [illegible]idly. Although every [illegible] the surface cells of an [illegible] graft may possibly survive.

The disadvantages are as follows: (*a*) to obtain the graft, an additional operative procedure is necessary; (*b*) there is the risk of a haematoma which may become infected, especially if the ilium is the donor site; and (*c*) the donor bone may later fracture, especially in the tibia. In spite of these disadvantages, autogenous grafts are usually best.

Sources of autogenous grafts are (*a*) the upper tibia, from which large pieces of

By removing a wedge of bone from two adjacent laminae in the lumbar spine, an angular lordosis may be produced.

HIP — Osteotomy is a common and important operation and is considered below.

SHAFT OF FEMUR — Osteotomy is occasionally required for congenital deformities, or those resulting from rickets, fibrous dysplasia or mal-union.

LOWER FEMUR — Genu valgum may be corrected by a supracondylar osteotomy, the correction being held in plaster. Similarly, a supracondylar osteotomy may be used to correct fixed flexion after inflammatory disease, or genu recurvatum after unbalanced paralysis. For genu varum (bow legs) tibial osteotomy is often preferred.

UPPER TIBIA — Osteotomy may be required for bow legs, angulation and rotation both being corrected. Great care is necessary to avoid damaging the bifurcation of the popliteal artery.

SHAFT OF TIBIA — Osteotomy may be necessary for old rickets or painful Paget's disease.

LOWER TIBIA — If mal-united, a Pott's fracture-dislocation may lead to osteoarthritis of the ankle. This can sometimes be prevented by an osteotomy three-quarters of an inch above the joint, the distal portion being angulated so as to bring the lower surface of the tibia horizontal.

FOOT — Osteotomies are frequently performed for talipes equinovarus deformity, claw foot and other deformities. Usually a wedge of bone is removed from the convex side of the deformity, the object always being to make the foot plantigrade.

TOES — Osteotomy of the first metatarsal is sometimes useful to correct hallux valgus in a young patient. Osteotomy has also been used to correct congenital elevation of the first metatarsal.

OSTEOTOMIES FOR HIP CONDITIONS

CONGENITAL DISLOCATION — At open reduction the hip is often found to be stable only in full internal rotation (because of anteversion of the neck). It is therefore held in plaster in that position. Six weeks later the upper femur is divided transversely; the limb below the osteotomy is externally rotated until the foot points forwards, and the osteotomy held by a plate and screws. Plaster is also required.

For an old unreduced dislocation the femur may be divided below the trochanters and the shaft abducted and held by a plate (Batchelor's operation). This gives some increase of stability and of apparent length.

Formerly bifurcation osteotomy (Lorenz) was used, the cut surface of the upper femur being thrust into the old acetabulum.

TUBERCULOSIS — After tuberculous arthritis the hip is often unsound, flexed, adducted and internally rotated, shortening may be severe. The shaft is divided below the great trochanter and flexion and rotation deformity corrected. The shaft is then angulated into abduction and held there in plaster; this angulation gives apparent gain in length. Not only does the osteotomy reduce deformity but sometimes the hip becomes sound. *Note* — Other inflammatory conditions may require a similar corrective osteotomy

In Brittain's operation, the upper femur is osteotomized and a bone graft inserted between the cut surfaces across to the ischium.

blades slightly closer together. In the absence of a really tight fit, screw fixation is advisable. A special type of inlay graft is the sliding graft sometimes used for non-union of a fractured long bone.

Another method of anchoring a graft is to drive it into the host bone medulla. The hold is not secure, but it must be remembered that no matter how securely any graft is fixed, external fixation is always essential.

IV: METAL IN BONE SURGERY

Metal is used extensively in surgery because of its strength, its relative inertness in the body and the ease with which it may be sterilized. Thus it is ideal for surgical instruments. The discussion which follows is concerned only with the use of metal which is left temporarily or permanently in the body.

INDICATIONS

SKELETAL TRACTION — Skeletal traction may be required for fractures of the lower limb and after injuries or operations in the region of the hip. A Kirschner wire, Steinmann pin or Denham pin is inserted at right angles to the limb usually through the upper tibia behind the tibial tubercle, but occasionally through the lower tibia or os calcis. Skeletal traction is often valuable, but care must be taken to avoid local sepsis, and in fractures there is always a danger of overpulling.

INTERNAL FIXATION — Internal fixation should only be used in the treatment of fractures if asepsis can be guaranteed and if a perfect reduction has been achieved. It may be used in the following circumstances.

(*a*) If closed reduction of a fracture is impossible and the fracture has to be openly reduced. It is then usually worthwhile fixing the fracture internally (for example, some fractures of the forearm bones and of the medial malleolus).

(*b*) If a fracture, even though it can be reduced by closed methods, cannot be adequately held without internal fixation (for example, a fractured olecranon process, and transcervical fractures of the femoral neck).

(*c*) If a fracture cannot be held by closed methods without jeopardizing the soft parts (for example, many fractures of the lower limb in elderly patients, and fracture of the spine with paraplegia).

Internal fixation is also sometimes used for conditions other than fractures; for example, for osteotomies, in compression arthrodesis, and as an internal splint of wire for toe arthrodesis. Metal staples may be used temporarily to retard growth at an epiphysis.

There are two kinds of internal metal fixation: (*a*) inlay, with a trifin nail, intramedullary nail or screws; and (*b*) onlay, which is always by a plate. Plates should be big and strong, and must be screwed to the opposite cortex.

ARTHROPLASTY — A metal cup may be used in arthroplasty of the hip and a metal prosthesis is sometimes used to replace the head of the femur in arthroplasty or following non-union of a transcervical fracture.

strong cortical bone and a few cancellous chips are obtainable, and (*b*) the posterior ilium, from which some cortical bone and many chips are obtainable.

HOMOGENEOUS

(*From another human*)

The advantages of homogeneous grafts are as follows: (*a*) an ample supply of cortical bone or chips is available without the patient having to undergo additional operative procedures; and (*b*) the grafts can be prefabricated to fit the host site.

The disadvantages are as follows: (*a*) homogeneous grafts "take" more slowly than autogenous grafts; (*b*) there may be slightly greater risk of sepsis; and (*c*) disease, such as tuberculosis, may be transplanted with the graft.

Sources of homogeneous grafts are (*a*) the fresh corpse of a reasonably young person without transmissible disease, and (*b*) ribs removed during thoracoplasty.

The bone may be stored in dilute Merthiolate solution, or in a deep freeze at −20° C., or it may be boiled immediately after removal, stored in a sterile container, and reboiled before use (the safest method but giving the slowest "take").

HETEROGENOUS

(*From a different species*)

Beef bone or ivory pegs and screws are hardly ever used because they "take" much too slowly, if at all.

INDICATIONS

A graft may be used primarily for splintage, for linkage, or for both.

SPLINTAGE — The graft may be required to stabilize a bone, as for an un-united fracture, or to stabilize a joint, as for arthrodesis When used for splintage, strong cortical grafts are required

LINKAGE — A graft may be required to bridge a bone gap—the gap may, for example, follow excision of a chondroma or cyst—or to bridge a joint gap; when arthrodesing a joint it is often necessary to pack bone chips into the dead space left after removing cartilage and diseased bone (this is in addition to the cortical graft used for splintage). The spine also often requires chip grafts in addition to cortical grafts.

TECHNIQUES

ONLAY

The cortical surface of the host bone is first rawed to provide a suitable bed. To this, chip grafts may be applied and held in place by suturing the soft tissues; a cortical graft is best held by screwing it to the host bone.

INLAY

Usually a cortical graft is fitted into a trench in the host bone. To obtain a snug fit the graft may be cut with a twin-bladed motor saw and the trench cut with the same

CLASSIFICATION

PROVISIONAL

A provisional amputation is performed where reamputation may be necessary [illegible]

Techniques of provisional amputation are as follows.

GUILLOTINE — All tissues are divided at the same level. Drainage is excellent, but a huge raw area remains. To minimize skin retraction and allow possible secondary suture, skin traction may be applied and tied to a truncated Thomas' splint.

CIRCULAR — Skin flaps sufficient to cover the deep tissues are cut, but only one central suture is inserted (possibly over a pack). Drainage is less adequate, but secondary suture is easier and healing more rapid.

DEFINITIVE: END BEARING

An end bearing amputation is performed when weight is to be taken through the end of a stump. Therefore, the scar must not be terminal, and the bone end must be solid, not hollow, which means it must be cut near an articular surface. Examples are Syme's amputation and Stokes-Gritti amputation, which are discussed on page 113.

DEFINITIVE: NON-END BEARING

Definitive non-end bearing amputations are much the commonest variety. All upper limb and most lower limb amputations come into this category.

Because weight is not to be taken at the end of the stump, the scar should be terminal; this may be achieved by cutting equal or nearly equal skin flaps. The bone may be cut at any convenient level, for it is no disadvantage if there is only a hollow ring of cortical bone at the end of the stump.

For the standard lower limb prostheses, amputations are designed to be tibial-bearing (taking weight through the expanded upper tibia) or tuber-bearing (ischial tuberosity) or both. Some weight may also be transmitted through the soft tissues by the use of a tight thigh corset.

AMPUTATIONS AT THE SITES OF ELECTION

The standard amputations are designed to be non-end bearing. The sites of election for amputation (that is, that which provides the ideal stump length) are as follows.

ABOVE KNEE — 11 inches below the top of the great trochanter.
BELOW KNEE — 5½ inches below the tibial plateau.
ABOVE ELBOW — 8 inches below the tip of the acromion process.
BELOW ELBOW — 7 inches below the tip of the olecranon process.

A shorter stump should be avoided because (a) it may lack control where muscle insertions [illegible] ant [illegible] of

DISADVANTAGES OF METAL

INFECTION — Bacteria may be introduced when the metal is inserted and may flourish in the haematoma. The remedy is not antibiotics but rigid asepsis. Once infection is established it is likely to persist until the metal is removed, because the metal acts as a foreign-body irritant. Some surgeons have advised plating compound fractures, but this is not a safe procedure.

INADEQUATE STRENGTH — Metal plates and screws are not strong enough to resist stresses at a fracture. External splintage is therefore also required until the fracture itself is united. When a fracture has been plated, the technique of "delayed splintage" is of great value (*see* page 256). The bone itself may be weakened by having too many screw holes drilled in it or cells may be burned by the speed of motor drills.

CORROSION — Corrosion may occur if the metal is not inert, or because of electrolysis between dissimilar metals. The corrosion may produce pain, a discharge or metal fracture. It is important therefore to use screws of the same metal as the plate, to *avoid depositing fragments of drill (which are usually of different metal), and to ensure* that if an implant is manufactured in separate parts they are all of the same material.

TYPES OF METAL USED

STAINLESS STEEL — Stainless steel is inert, strong and fairly easy to machine. It is, however, an alloy, there being many stainless steels of varying composition, so that unless an exact specification is insisted upon dissimilar metals may be inserted if they happen to come from different manufacturers, or even from different batches from the same manufacturer.

VITALLIUM — Vitallium is also inert and strong, but has to be cast because it is too hard to machine. Although it is an alloy its composition is constant because it is manufactured under patent by only one company. When other firms are allowed to make it, variations are likely to appear.

TITANIUM — Titanium is not only inert, strong and easily machined, but it is a single element and not an alloy It is therefore not subject to variation. At present its use is still experimental but it holds much promise for the future.

V: AMPUTATIONS

INDICATIONS

(*a*) DEAD LIMB — This may be due to *severe trauma*, especially to blood vessels, *gangrene*, due to arteriosclerosis, embolism or thrombosis, or diabetic gangrene.

(*b*) LETHAL LIMB — This is a limb which may kill the patient because of a *malignant tumour*, *severe sepsis*, especially gas gangrene, or a *crush injury*, in which releasing the compression force may result in renal failure (crush syndrome).

(*c*) NUISANCE — This is a limb which is inferior to an artificial limb or worse than no limb at all. This may be because the limb is *painful*, *useless*, that is, too flail or too stiff, or *septic*; a leg with recurrent flares from osteomyelitis may be more nuisance than it is worth.

NOTE that (*a*) and (*b*) are absolute indications, (*c*) is a relative indication.

measured from the front of the flexed elbow. Long below-elbow amputations are no better than those of standard length for pronation and supination cannot be usefully employed with a prosthesis.

AMPUTATIONS IN THE HAND — These operations are discussed on page 152.

LOWER LIMB

HINDQUARTER AMPUTATION — This operation is only performed for malignant disease. Sir Gordon Gordon-Taylor's technique should be followed in detail.

DISARTICULATION THROUGH THE HIP — This is rarely indicated and very difficult to fit with a prosthesis. If the femoral head, neck and trochanters are retained it is possible to fit a tilting-table prosthesis in which the upper femur sits flexed.

THIGH AMPUTATIONS — The longer the stump the better can the patient control a prosthesis; with less than about 7 inches from the top of the great trochanter it is difficult to keep the stump in the socket (the length varies according to whether the patient is fat or thin). In a long above-knee amputation at least 3 inches should be cut off the femur to provide room for the artificial knee mechanism.

AROUND THE KNEE — The classical amputation is the Stokes-Gritti operation. By having a long anterior flap (containing the patella), the scar is brought to the back of the stump. To provide a broad area of solid bone the femur is divided just above the condyles. The rawed patella is fixed to the cut surface of the femur. It is not easy to make the patella fuse to the femur, and if a jointed prosthesis is fitted, the knee joint is lower than the other side. Nevertheless it is a good amputation, providing a conical stump capable of end bearing and suitable for fitting in a peg leg.

Two other amputations around the knee are also designed for end bearing and both have long anterior flaps. They are (*a*) through the knee; this is easy to do, and is becoming more popular, especially in children; and (*b*) kneeling stump; a very short below-knee amputation (1 inch of tibia) enables the patient to take weight by kneeling on a peg leg.

BELOW-KNEE AMPUTATIONS — If they can be fitted with a satisfactory prosthesis, these operations give excellent function, and the gait is scarcely distinguishable from normal. Even a very short stump may be worthwhile; 2 inches of tibia in the stump may enable it to be retained in the socket if the patient is thin, and every half inch longer is an advantage. There is little advantage, however, in a stump longer than the ideal of 5½ inches, for the controlling muscles are all attached proximally, and long stumps tend to suffer from circulatory troubles.

ABOVE THE ANKLE — Syme's amputation is sometimes very satisfactory, providing the circulation of the limb is good. The indications are few, and the operation is difficult to do well. Because the stump is designed to be end bearing, the scar is brought away from the end by cutting a long posterior flap. This flap must contain not only the skin of the heel, but also all the fibrofatty tissue, to provide a good pad for weight bearing, and therefore in cutting the flap the bone must be picked clean. The bones are divided just above the malleoli to provide a broad area of cancellous bone, to which the flap should stick firmly, otherwise the soft tissues tend to wobble about. Pirogoff's amputation is similar in principle to Syme's, but is rarely performed. The back of the os calcis is stuck on to the cut end of the tibia and fibula.

the socket of a prosthesis; and (*c*) not unnaturally the patient prefers to retain as much as possible of his own tissues.

A longer stump is not advisable because (*a*) the longer the stump the worse the circulation. This particularly applies to below-knee stumps; for arteriosclerosis many surgeons advise above-knee amputation; (*b*) the distal end may contain unnoticed infected or malignant material; in sarcoma, most authorities advise amputation at least through the joint above the tumour; and (*c*) too long a stump leaves insufficient room for the limbmaker's gadgets, such as an artificial joint.

PRINCIPLES OF TECHNIQUE

A tourniquet is used unless there is arterial insufficiency. Skin flaps are anterior and posterior; in the upper limb they are semicircular and equal; above the knee many surgeons prefer a longer anterior flap, and below the knee a longer posterior flap.

Deep fascia is reflected as a separate layer.

Muscles are divided at the proposed site of bone section; they subsequently retract, so helping to make the stump conical. Tendons and nerves are divided at the same level without special attention.

Bone is sawn across at the proposed level. In below-knee amputations the front of the tibia is bevelled and the fibula cut an inch shorter.

The main vessels are tied, the tourniquet removed, and every bleeding point meticulously ligated.

The deep fascia is sutured as a separate layer, to enable skin to glide freely over the deep structures.

The skin is sutured carefully without tension and without dog ears.

Drainage for 24–48 hours is usually advised. The stump is bandaged firmly to control bleeding and to help make it conical.

AFTERCARE

If a haematoma forms, it is evacuated at 5–6 days from operation.

Once the stump has healed, it is bandaged repeatedly and firmly so as to make it conical. A temporary conical pylon is another method of shaping the stump.

The joint above the amputation stump must be kept mobile and the muscles which control the stump are exercised. Finally the patient is taught to use his prosthesis.

AMPUTATIONS OTHER THAN AT THE SITES OF ELECTION

UPPER LIMB

FOREQUARTER AMPUTATION — This operation is a mutilating procedure and only done in the hope of eradicating malignant disease; therefore, after the forequarter has been removed, malignant lymph nodes in the neck must be sought.

DISARTICULATION AT THE SHOULDER — This operation is rarely indicated, and if the head of the humerus can be left, the appearance is much better. If an inch of humerus can be left below the anterior axillary fold, it is possible to hold the stump in a prosthesis.

BELOW THE ELBOW — The shortest stump which will stay in a prosthesis is an inch

JOINT — The joint above an amputation may be stiff or deformed. A common deformity is fixed flexion and fixed abduction at the hip in above-knee stumps (because the adductors and hamstring muscles have been divided). It should be avoided by exercises. If it becomes established, subtrochanteric osteotomy may be necessary. Fixed flexion at the knee makes it difficult to walk properly and should also be avoided.

BONE — If the amputation was for osteomyelitis, the bone infection may flare, giving pain and sometimes a sinus. Antibiotics or sequestrectomy may be necessary.

A spur often forms at the end of the bone, but is usually painless. If there has been infection, however, the spur may be large and painful and it may be necessary to excise the end of the bone with the spur.

Suggestions for further reading

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PARTIAL FOOT AMPUTATIONS — These operations are not popular because the tendo achillis tends to pull the foot into equinus. This deformity can be avoided by splintage, tenotomy, or tendon transplants and if so, these amputations may be satisfactory. The foot may be amputated at any convenient level, such as through the mid-tarsal joints (Chopart), through the tarsometatarsal joints (Lisfranc), or through the metatarsal bones themselves. It is best to disregard the classical descriptions and to leave as long a foot as possible providing it is plantigrade and that an adequate flap of plantar skin can be provided.

IN THE FOOT — Amputation of an entire ray, that is, a toe and its metatarsal bone, is useful in treating a perforating ulcer.

COMPLICATIONS OF AMPUTATION STUMPS

SKIN — Eczema is common. Ultraviolet light or ointments sometimes help but it may be necessary to leave off the prosthesis for a time.

The socket of an above-knee prosthesis may rub the groin and tender purulent lumps ("boils") develop. A rest from the prosthesis, or a better fitting one, may be necessary.

Callosities may develop below the knee if a patient is taking weight on the expanded upper tibia. He should be fitted with an ischial-bearing prosthesis.

Ulceration is usually due to poor circulation and reamputation at a higher level is then necessary. If, however, the circulation is satisfactory and the skin around an ulcer is healthy, it may be sufficient merely to excise an inch of bone and resuture.

MUSCLE — If too much muscle is left at the end of the stump, the resulting unstable "cushion" induces a feeling of insecurity which may prevent proper use of a prosthesis; if so, the excess soft tissue must be excised.

ARTERY — Poor circulation gives a cold, blue stump which is liable to ulcerate. This problem chiefly arises with below-knee amputations and often reamputation is necessary.

NERVE — A cut nerve always forms a neuroma and occasionally the neuroma is painful and tender. Probably the pain is caused by the neuroma adhering to other structures so that it is pulled on whenever the stump moves inside the socket. The treatment is to excise an inch of the nerve well above the neuroma.

True neuritis (nerve inflammation) may follow amputation for sepsis. There is spontaneous pain and tenderness, and a prosthesis cannot be worn until the inflammation and pain subside

"Phantom limb" is the term used to describe the feeling that a patient has that his limb is still present after it has been amputated. The patient should be warned of this sensation before amputation and told that it will gradually recede. Eventually it should either disappear or cease to disturb the patient.

A painful phantom limb is very difficult to treat; intermittent percussion to the end of the stump has been recommended both for phantom limb and for painful neuroma, it sounds brutal but success is claimed.

Occasionally a limb jumps about when touched (jactitation). This is said to be a psychological disorder, but it is worth trying to deal with any cause of tenderness.

For the remaining active movements the patient is asked to move his arm across the front of the body (adduction), to bring both arms forwards until the hands point to the ceiling (flexion), and backwards as far as possible (extension). External rotation is tested by asking him to tuck his elbows into his sides, bend them to 90 degrees, and then separate his hands; and internal rotation by asking him to scratch the opposite shoulder blade from behind.

(2) *Passive movements* — Here again, abduction is the most important movement. If the patient is unable to abduct his arm fully, passive abduction is tried. With a complete tear of the supraspinatus tendon, active abduction is grossly limited, but passive abduction is full. Internal and external rotation may also be examined passively.

(3) *Glenohumeral movements* — If movement at the shoulder is limited, glenohumeral movement is tested separately, for, even when the glenohumeral joint has been arthrodesed, the arm can be raised to nearly 90 degrees; the scapula is therefore anchored with one hand while the other moves the patient's arm.

X-RAY — The antero-posterior view is the most useful. The film is examined in an orderly sequence, noting the density as a whole, the joint position and line, and the detail of the individual bones. A calcified area may be seen just above the great tuberosity.

SCAPULAR DISORDERS

SPRENGEL'S SHOULDER (CONGENITAL UNDESCENDED SCAPULA)

CAUSE

The scapula should normally have completed its descent from the neck by the third month of foetal life. Rarely it remains unduly high.

SYMPTOMS

Deformity is the only symptom, even though movement is limited.

SIGNS

LOOK — The shoulder on the affected side is higher and a "web" of skin may run from it to the side of the head.

FEEL — The scapula feels abnormally high and is small.

MOVE — Movements are painless, but abduction is considerably limited because there is little scapulothoracic movement.

X-RAY — This often shows abnormalities of ribs and vertebrae (for instance, spina bifida or hemivertebra).

TREATMENT

Several operations for freeing the scapula and anchoring it lower down have been described. In boys they are not worthwhile because the disability from a Sprengel's shoulder is slight. Even in girls there is not much advantage in correcting the deformity at the cost of a scar, but if the scapula can be successfully brought lower the patient's appearance is improved.

NOTE — In the Klippel-F[illegible]
patient looks as if he [illegible]

CHAPTER 12

THE SHOULDER JOINT

EXAMINATION OF THE SHOULDER

SYMPTOMS

PAIN is not often felt at the point of the shoulder or anteriorly. More usually it is felt at the insertion of the deltoid muscle and radiates to the outer side of the elbow and to the dorsum of the forearm and wrist.

Stiffness may cause difficulty in dressing, brushing the hair, or any other activity in which the arm is raised.

Weakness is only occasionally a symptom.

SIGNS

LOOK

Skin — Scars or sinuses are noted.

Shape — There may be wasting of the deltoid muscle. When the acromioclavicular joint is dislocated, the outer end of the clavicle forms an obvious lump.

Position — The position in which the arm is held may be of diagnostic value.

FEEL

Skin — Because the joint is well covered inflammation does not influence the skin temperature

Soft tissues — Fluid and synovial thickening are not detectable. Muscle bulk and tautness, especially of the deltoid muscle, are tested.

Bony points — The clavicle, acromion process and humeral head are systematically palpated. Tenderness is sometimes difficult to localize.

MOVE — Shoulder movements are complicated because there are, in effect, two joints (glenohumeral and scapulothoracic) and two groups of controlling muscles. The superficial muscle (deltoid) is mainly concerned with movement; it may be wasted or paralysed. The deep group (musculotendinous cuff) are fixators, anchoring the humeral head while the deltoid muscle contracts; in this group the supraspinatus may be torn or degenerate. A bursa (subdeltoid) permits differential movement between the two groups. Because of these facts, movements should be examined in three stages.

(1) *Active movements* — Abduction is the most important. The patient is asked to raise his arms sideways until they point to the ceiling. Abduction may be (*a*) diminished in range; (*b*) painful; (*c*) altered in rhythm, that is, the scapula begins to move too early, producing a shrugging effect; or (*d*) reduced in power, that is, it cannot be achieved against resistance.

LOOK — A sinus may be present, but the striking feature is marked wasting of the deltoid muscle and, to some extent, of the scapular muscles.
FEEL — There may be diffuse tenderness.
MOVE — All movements are considerably limited and may cause pain.
X-RAY — Generalized rarefaction is present, usually with some erosion of both joint surfaces; there may be a ragged abscess cavity in the humeral head.

TREATMENT

In addition to general treatment a plaster may be applied with the shoulder in 70 degrees [illegible] the coronal plane and in midrotation, and with [illegible] fibrosis and, because of the prolonged action of [illegible] elongates, so that some surgeons are content merely to rest the arm in a sling from the start.

If flares subsequently occur, or if the shoulder continues to be painful, the joint is arthrodesed by turning down the outer end of the acromion process and clavicle and embedding them into the humeral head.

MUSCULOTENDINOUS CUFF LESIONS

The supraspinatus, infraspinatus, subscapularis and teres minor muscles become tendinous at their outer ends, and the tendons blend with the capsule to form a cuff. This tendinous area, and especially the supraspinatus tendon, is liable to a variety of lesions. The differing clinical pictures stem directly from the underlying pathology; in all cases there is a mixture of three possible factors—degeneration, trauma and reaction.

Degeneration — A large tendon is liable to avascular necrosis because sufficient blood cannot penetrate to its centre. The supraspinatus tendon in particular becomes degenerate with advancing age. At autopsy, areas of avascular degeneration are commonly seen even in people who have never complained of their shoulders. As in other avascular areas, calcification may occur.

Trauma — The supraspinatus tendon is liable to injury if its contraction is resisted. This may occur when lifting a heavy weight, or when the arm is used to save the patient when falling. It is very difficult to injure the cuff unless it is already degenerate; and the more degenerate it is the more easily it tears.

Reaction — In an attempt to repair a torn tendon or to revascularize a degenerate area, new blood vessels grow in; probably it is this "inflammatory reaction" which results in pain.

WEAR, TEAR AND REPAIR — The three pathological processes may be summed up as "wear", "tear" and "repair". Wear and tear are certainly accurate. The process of repair is less convincing as an explanation; nevertheless, much of the confusion in explaining cuff lesions vanishes if it is assumed that (*a*) an inflammatory type of reaction does occur; (*b*) in the young the reaction is more vigorous than in the aged; and (*c*) that the reaction produces pain. Thus, in the young, an area of degeneration may calcify and provoke an exaggerated reaction (acute tendinitis); pain is severe but recovery rapid and complete. In the elderly, on the contrary, a large tear may occur through tendon so avascular that

gross limitation of movement. Other congenital abnormalities are present. Bilateral shortness of the sternomastoid muscle is another rare condition in which the patient looks as if he has scarcely any neck; but his head is poked forwards and his chin sticks up in the air; in contrast with the Klippel-Feil syndrome, usually there are no associated congenital deformities.

WINGED SCAPULA

CAUSE

The serratus anterior muscle is paralysed, usually by trauma from carrying a heavy weight on the shoulder or from damage to the long thoracic nerve during radical mastectomy. Traumatic rupture of the muscle has been described.

SIGNS

The patient is asked to raise his arms 90 degrees and to push with his hand against a wall. Winging (backward projection of the vertebral border) then becomes obvious. Movements are usually full and power only slightly reduced.

TREATMENT

The disability is slight and is best accepted, although attempts have been made to anchor the scapula to the spinous processes.

GRATING SCAPULA

This condition mainly affects young women, who complain of noisy grating or clicking on moving the arm. It is painless, and the cause is unknown, though bony, muscular, or bursal abnormalities have been blamed. No treatment is advised.

TUBERCULOSIS OF THE SHOULDER

(*See also* page 27)

PATHOLOGY

Although the disease process starts as a synovitis or osteomyelitis, it is rarely seen until arthritis has supervened. Abscess and sinus formation are quite common (florid type). If there is no discharge at any stage the term "caries sicca" is used; one suspects, however, that many cases of reputed caries sicca are really examples of frozen shoulder.

SYMPTOMS

A fairly constant grumbling ache may last many months or years, and the patient may complain of stiffness.

SIGNS

Adults are mainly affected. The general signs of tuberculosis are often slight, though pulmonary tuberculosis may coexist.

TREATMENT

EARLY CASES — In early cases repair is desirable. The tear may be exposed by a sabre-cut incision and strong mattress sutures used to reattach the supraspinatus tendon to the great tuberosity. The sutures are liable to cut out because the tendon is degenerate.

Repair should not be attempted unless the patient is seen early and is fairly young, both uncommon features. Moreover, repair is unnecessary unless the tear really is complete. It is not easy in the early stages to distinguish a complete from a partial tear because, in both, pain prevents even passive abduction. To test for completeness, local anaesthetic should be injected until pain is abolished. If the patient can then abduct without shrugging, the tear is partial.

LATE CASES — In late cases repair is inadvisable and probably impossible. Because the condition is painless, conservative treatment also is unnecessary. The patient learns trick movements and usually achieves useful function.

PARTIAL TEAR

Degeneration is moderate in amount.

The trauma necessary to produce a partial tear need only be trivial.

The reaction is also moderate in amount; blood vessels grow in and there is a swelling localized to the affected area.

SYMPTOMS

The patient, usually aged 45–60 years, sustains an injury which is often no more than a "sprain". This is followed by pain and inability to lift the arm. Pain is usually felt at the deltoid insertion and radiates to the outer side of the elbow and posterior aspect of the forearm and wrist. Later symptoms depend upon which of the three possible sequels follows the "reaction" (*see* below).

EARLY SIGNS

LOOK — The appearance is normal.

FEEL — Tenderness may be localized to just below the tip of the acromion process or it may be diffuse.

MOVE — Active abduction is limited and painful; the rhythm is faulty and power reduced. Passive abduction also is limited by pain. (These signs are the same as those of an early complete tear, and the test for completeness, already described, may be necessary.)

X-RAY — No abnormality is seen.

SEQUELS

The extent and effectiveness of the reaction determines which of three possible sequels occurs: (*a*) complete recovery; (*b*) persistence of local swelling in the damaged tendon (chronic tendinitis), giving a painful arc of movement; (*c*) spread of the reaction to the entire cuff and bursa (frozen shoulder).

TREATMENT

No attempt is made to suture a partial tear. In addition to analgesics, the three pillars of conservative treatment for pain due to any cuff lesions are as follows.

little or no reaction is possible (complete tear); there is, after a few days, no pain, but neither is there any recovery; the weakness is permanent.

Between these comparatively rare extremes lies a variety of conditions of middle life: the reaction to degeneration or injury may remain localized (painful arc), may spread to the biceps tendon (biceps tendinitis) or may extend to the entire cuff (frozen shoulder). In all these conditions, because the reaction is necessarily slow, pain tends to last several months, but eventually recovery takes place.

COMPLETE TEAR

The term "complete" does not mean that the entire cuff is torn (a very rare lesion) but that the entire supraspinatus tendon is torn.

PATHOLOGY

Degeneration is a prominent and well marked feature.

Trauma, not necessarily severe, must have occurred. The supraspinatus tendon tears about half an inch from its insertion, but after a time the distal stub is rubbed away.

The reaction is slight or absent, and no repair occurs.

SYMPTOMS

The patient, often a manual labourer, and usually aged 55–65 years, is lifting a weight or protecting himself when falling. He feels immediate pain and loss of power. Later the pain goes but weakness persists.

EARLY SIGNS

Only rarely is the patient seen soon after injury. If he is, the signs are as follows.

LOOK — The shoulder appears normal.

FEEL — Occasionally a gap can be felt below the acromion process and usually there is diffuse tenderness.

MOVE — Active abduction is impossible and passive abduction is prevented by pain; so that in this early stage the condition must be distinguished from a partial tear (*see* page 121).

X-RAY — It is essential to exclude bony injury.

LATE SIGNS

The patient is rarely sent to hospital until after several weeks, by which time the classical signs of a complete tear are present.

LOOK — There may be a slight hollow in the supraspinous fossa.

FEEL — No abnormality can be felt.

MOVE — Active abduction is impossible and attempting it produces a characteristic shrug. [illegible]

X-RAY — Nothing abnormal is seen.

PATHOLOGY

Degeneration is often no more than moderate in amount.

Trauma is almost certainly a factor. It should be noted that while frozen shoulder may follow a partial tear, it never occurs after a complete tear.

The reaction is peculiar and not fully understood. The entire cuff is infiltrated with lymphocytes and plasma cells.

SYMPTOMS

The condition occurs between the ages of 50 and 60 years in men, slightly earlier in women, and still earlier in patients of either sex in the presence of cardiovascular disease.

There may be a history of trauma, often trivial, followed by pain and stiffness. The pain is felt at the deltoid insertion and radiates along the outer side of the arm to the back of the forearm and hand. It gradually increases in severity and often prevents the patient from sleeping on the affected side. Over several months it slowly subsides. Stiffness also increases in severity for some months, and becomes more and more of a handicap. It outlasts the pain by a few months, then gradually movement returns, almost to normal.

There are thus three phases: (1) increasing pain and increasing stiffness; (2) decreasing pain with persistent stiffness; (3) painless return of almost full movement. Each phase lasts 4–8 months.

SIGNS

LOOK — Occasionally there is slight wasting of the spinati muscles.

FEEL — Tenderness may be felt below the acromion process or in front.

MOVE — In a severe case movements, both active and passive, are grossly restricted in all directions from the sling position. With recovery the range slowly increases. (There is great variation in the severity of frozen shoulder. In the mildest type there may be only slight restriction of the extremes of range, with gradual recovery after a few months.)

X-RAY — The x-ray appearance of a frozen shoulder is widely accepted as normal; but usually there is a little rarefaction beneath the great tuberosity.

DIFFERENTIAL DIAGNOSIS

The following conditions must be distinguished from frozen shoulder.

POST-TRAUMATIC STIFFNESS — After bony injury (such as a fractured neck of humerus) stiffness may persist for some months. There is, however, a history of injury followed by a bruise; the stiffness is maximal at the start and gradually lessens (unlike the pattern of a frozen shoulder), and x-rays may show the fracture.

TUBERCULOSIS — Although tuberculosis, like frozen shoulder, has a long history of ache and stiffness, it differs in that wasting is much more marked and x-rays show bone destruction.

OSTEOARTHRITIS — Contrary to popular belief, osteoarthritis of the shoulder is rare, probably because extremes of shoulder movement are rarely used. It should not be diagnosed unless the phasic story of a frozen shoulder is lacking and x-rays show osteo-

HEAT — Infra-red or short-wave diathermy is given.

EXERCISES — In the hope of preventing stiffness, the patient is taught exercises within the limits of pain. The most useful are "pendulum" exercises, in which the patient leans forward at the hips and moves his arm as if stirring a giant pudding.

INJECTIONS — A fashionable "cocktail" contains a local anaesthetic (10 ml. of 1 per cent Xylocaine), a spreading agent (1 ampoule of hyaluronidase, containing 1,000 Benger units) and a fibrous tissue suppressor (2 ml. of hydrocortisone acetate, containing 50 mg). This mixture is injected into the tender area and, if benefit follows, may be repeated after 3 weeks.

CHRONIC TENDINITIS (PAINFUL ARC)

PATHOLOGY

Degeneration is moderate in amount.

Trauma may or may not have occurred. (Chronic localized tendinitis may be the sequel to a partial tear, or may arise insidiously.)

The reactionary response consists of swelling localized to the abnormal area of the supraspinatus tendon.

SYMPTOMS

The patient, usually aged 45–60 years, complains that certain movements and certain positions of the shoulder are painful. These symptoms come on gradually or may follow a few weeks after an injury.

SIGNS

LOOK — The shoulder looks normal.

FEEL — There may be tenderness below the acromion process or further forwards.

MOVE — In mid-abduction there is a painful arc of movement, often with a characteristic jerk as the affected area of tendon comes into contact with the under surface of the acromion process Once this point is passed abduction is painless, because the swollen area is no longer pressing against bone.

If the tendinitis has followed a partial tear, there may also be some loss of power and faulty rhythm.

X-RAY — Usually the appearance is normal, but occasionally calcification just above the great tuberosity is seen.

TREATMENT

Conservative treatment is nearly always sufficient and consists of heat, exercises in which the patient is taught to avoid the painful arc, and local injections of the "cocktail". Very rarely, if pain is severe and persists in spite of conservative treatment, the acromion process may be excised

FROZEN SHOULDER

This is also known as chronic bursitis, periarthritis, and adhesive capsulitis.

to aspirate the toothpaste-like calcified material. This can rarely be withdrawn, even with a wide-bore needle; however, the attempt probably relieves tension by facilitating eruption into the bursa.

If symptoms are severe, rapid relief is obtained by operation. Through a small vertical incision just below the acromion process the deltoid fibres are separated and, on rotating the humerus, the affected area of tendon is seen. The calcified material is scooped out. This gives immediate and complete relief.

LESIONS OF THE BICEPS TENDON

PRIMARY TENDINITIS

This follows unaccustomed use, such as home decorating or vigorous tennis, in patients aged 30–40 years. The shoulder is normal except for pain on external rotation and tenderness in the bicipital groove. Rest and local heat are usually sufficient treatment, but if recovery is delayed local anaesthetic injections or deep transverse frictions to the tender area are useful.

SECONDARY TENDINITIS

In some cuff lesions the reaction to degeneration spreads to the biceps tendon. Signs of biceps tendinitis are added to those of the underlying lesion, and both conditions may require treatment.

RUPTURED BICEPS TENDON

It used to be thought that the tendon of the long head of the biceps ruptured because it rubbed against osteophytes in an osteoarthritic shoulder. Most orthopaedic surgeons now agree that it is simply a tear through an area of avascular degeneration, comparable to that occurring in the supraspinatus tendon.

The patient is always over 50 years old. While lifting he feels something snap and the shoulder, which previously felt normal, aches for a time. Soon this ache disappears and good function returns. The clinical picture is unmistakeable. The belly of the muscle is too low; and when in action it does not tauten properly and looks semicircular instead of semioval. Shoulder movements are normal and no treatment is required.

BRACHIAL NEURALGIA

The term "brachial neuralgia" is usually applied to pain extending over a large part of the upper limb. The common causes may conveniently be classified on an anatomical basis.

DISORDERS AROUND THE SHOULDER

In all these, movement at the shoulder joint itself is painful or limited.

MUSCULOTENDINOUS CUFF — The onset of cuff lesions may be gradual or follow trauma, often trivial. X-rays show calcification or no abnormality.

phytes. If there is subsequent recovery of painless movement it indicates that the true diagnosis of frozen shoulder has been missed.

TREATMENT

Conservative treatment aims at alleviating pain while recovery is awaited; and it is important to reassure the patient that recovery is certain. In addition to analgesics, heat (such as short-wave diathermy) is sometimes soothing. Gentle exercises, especially pendulum movements within the painless range, are encouraged, but the patient should not force movement. Injections of the local anaesthetic "cocktail" sometimes help, and occasionally deep x-ray therapy gives relief.

Manipulation under anaesthesia is usually not advised until the phase of returning movement, and is then necessary only if movement is returning too slowly. However, much earlier manipulation is probably safe provided it is gentle and accompanied by the injection of hydrocortisone and Xylocaine.

ACUTE TENDINITIS (ACUTE CALCIFICATION)

PATHOLOGY

Degeneration in a small localized area of the supraspinatus tendon probably accounts for the deposition of calcium.

Trauma is an insignificant factor.

The reaction is tremendous. There is rapid swelling, and tension within the tendon rises, like a boil before it bursts. Once the calcified substance has erupted into the bursa, tension and pain quickly subside and the calcium is absorbed.

SYMPTOMS

A young adult, aged 25–45 years, whose shoulder previously felt normal, complains of dull aching sometimes following slight overuse. Hourly the pain increases in severity, and it may become agonizing. After a few days, pain subsides and the shoulder then returns to normal. In some patients the process is less dramatic; pain is less severe and recovery slower.

SIGNS

LOOK — The patient holds the arm immobile.

FEEL — Palpation, if permitted, must be very gentle.

MOVE — Active abduction is very painful and, if the condition is severe, movement is impossible.

X-RAY — Calcification is always present and shows as a small dense area just above the great tuberosity. As pain subsides the calcium appears to have spilt into the subdeltoid bursa; eventually it disappears.

TREATMENT

The patient is given morphia and a sling; spontaneous recovery usually occurs within a very few days and full shoulder movements return. Relief of pain can often be hastened by injecting local anaesthetic into the affected area and then attempting

Suggestions for further reading

Furlong, R. (1952). "The Painful Shoulder." *Ann. R. Coll. Surg. Engl.*, **11**, 300.

M'Laughlin, H. L. and Asherman, E. G. (1951). "Lesions of the Musculotendinous Cuff of the Shoulder." *J. Bone Jt Surg.*, 33A, 76.

Moseley, H. F. (1953). *Shoulder Lesions.* 2nd Ed. New York; Hoeber.

Simmonds, F. A. (1949). "Shoulder Pain and Frozen Shoulder." *J. Bone Jt Surg.*, 31B, 426.

Withers, R. J. W. (1949). "The Painful Shoulder." *J. Bone Jt Surg.*, 31B, 414.

BONES — A fracture may have been missed. The history is one of injury followed by a bruise, and x-rays show the fracture.

JOINT — (*a*) In tuberculosis the onset is gradual, muscle wasting marked and x-rays show bone destruction; (*b*) in rheumatoid arthritis, other joints are also affected; (*c*) pyogenic arthritis rarely occurs and is liable to give a totally stiff but painless shoulder; (*d*) osteo-arthritis is also a rarity.

DISORDERS PROXIMAL TO THE SHOULDER

In all of these, the shoulder itself has normal movement and a normal x-ray appearance.

TRUNK — Disorders of the diaphragm, heart, pericardium or pleura may cause pain in the arm. Usually the cause is clinically apparent, though x-rays of the chest are often helpful.

NECK — (*a*) Disc disorders (prolapse or spondylosis) may cause pain and weakness or numbness in the appropriate root distribution, usually C.6 or C.7; neck movements are limited and the disc spaces narrowed on x-ray; (*b*) vertebral disease, such as tuberculosis, may cause limited neck movement, there is sometimes an abscess, and x-rays show bone destruction affecting two adjacent vertebrae; (*c*) vertebral-body tumours may cause limitation of neck movements and root symptoms, and x-rays show that one body only is affected; (*d*) cord or root tumours have a gradual onset and a characteristic distribution of neurological signs.

NECK-ARM JUNCTION — (*a*) With a cervical rib, pain is usually ulnar in distribution and any wasting is in the small muscles of the hand (first thoracic nerve)—the rib or a large transverse process may show on x-ray; (*b*) in Pancoast's syndrome there is a hard lump at the root of the neck and x-rays show a bronchial carcinoma.

DISORDERS DISTAL TO THE SHOULDER

In these, the shoulder and neck move normally and the x-ray appearance is normal.

ELBOW — Pain from a tennis elbow may radiate to the entire limb, but tenderness is localized to the lateral epicondyle and there is pain on dorsiflexing the wrist against resistance.

WRIST — The pain in carpal tunnel syndrome is mainly in the median area of the hand and is worse at night. Any wasting is of the opponens pollicis muscle.

INVESTIGATION

It will be apparent from the above account that to investigate the cause of brachial neuralgia the following points must be considered.

HISTORY — Was there an injury? What is the nature and distribution of pain?

GENERAL FEATURES — What is the patient's age? Is there any evidence of general disease?

LOCAL FEATURES — Is there limitation of neck movement? Is there limitation of shoulder movement? Can the distribution of any neurological signs be related to a single peripheral nerve or root? Are there abnormal x-ray findings in the neck or shoulder?

TREATMENT

If severe, the deformity is corrected by a wedge osteotomy of the lower humerus. The arm is held in plaster in full extension and slight valgus.

CUBITUS VALGUS

CAUSE

The common causes are non-union of a fractured lateral condyle or mal-union of a fractured neck of radius.

SYMPTOMS

If it is due to an un-united lateral condyle, the valgus deformity is often gross and a mobile bony knob can be felt on the outer side. The deformity itself rarely attracts attention but, years after the injury, the patient may develop symptoms of ulnar nerve palsy; these are, tingling and numbness in the ulnar fingers, and weakness.

TREATMENT

The deformity is usually ignored; if ulnar nerve disturbance has occurred, the nerve may be transposed to the front of the elbow.

DISLOCATED HEAD OF RADIUS

CAUSE

The condition may be congenital, or may follow an unreduced Monteggia fracture-dislocation.

SYMPTOMS

Often there are no symptoms, but the patient may notice limitation of flexion.

SIGNS

When the elbow is straight a lump is visible in front; it is bony and moves when the forearm rotates. X-rays show the head of the radius to be dislocated forward, and there is usually a forward curve of the ulna.

TREATMENT

Often no treatment is necessary, but sometimes the head of the radius may need to be excised.

STIFFNESS OF THE ELBOW

Stiffness of both elbows may occur in rheumatoid arthritis, rarely in ankylosing spondylitis and, very rarely in Great Britain, as a complication of smallpox. If both elbows are completely stiff at inconvenient angles, disability is severe and arthroplasty of one elbow is worthwhile; the resulting joint is unstable but mobile and can be placed in various positions with the other hand.

Stiffness of one elbow, even if gross, is not necessarily much of a disability, for

CHAPTER 13

THE ELBOW JOINT

EXAMINATION OF THE ELBOW

SYMPTOMS

THE common symptoms of elbow disorders are pain, stiffness, deformity and occasionally locking. Pain at the elbow may be referred from neck or shoulder disorders; numbness or weakness of the hand may be the result of elbow disorders.

SIGNS

LOOK — The patient holds his arms alongside his body with palms forwards. Varus or valgus deformity is then obvious, but it cannot be accurately assessed unless the elbow is straight. He then holds his arms out sideways at right angles to the body with palms upwards and elbows straight. In this position, wasting or lumps are easily seen.

FEEL — The back and sides of the joint are palpated for warmth, tenderness (which must be accurately localized) and fluid, and to determine whether the bony points are correctly related.

MOVE — Flexion and extension are compared on the two sides. Then, with the elbows tucked into the sides and flexed to a right angle, the radio-ulnar joints are tested for pronation and supination.

X-RAY — Generalized bone density is first noted, then the joint position and the joint line and space are assessed. Next, the individual bones are inspected for evidence of old injury or bone destruction. Finally, loose bodies are sought.

NOTE — Where appropriate, other parts are examined; the neck (for cervical disc lesions), the shoulder (for cuff lesions) and the hand (for nerve lesions).

ELBOW DEFORMITIES

CUBITUS VARUS

CAUSE

Mal-union of a supracondylar fracture is the commonest cause.

SYMPTOMS

The deformity is ugly and the hand brushes against the body in walking.

SIGNS

Movements are not restricted, but with the elbow held straight the varus deformity is obvious.

Healing is by fibrosis. The fibrous tissue gradually elongates because of the weight of the arm; hence the need to splint the elbow well above the right angle during the acute stage.

OSTEOARTHRITIS

CAUSE

At the elbow osteoarthritis is rare. It may result from articular damage when the joint contains a loose body (especially with osteochondritis dissecans) or it may follow severe fractures.

SYMPTOMS

The symptoms are few. Until stiffness is considerable it often passes unnoticed. There is rarely much pain; occasionally the joint may lock. Symptoms of ulnar palsy may be present.

SIGNS

The joint is held flexed and may be somewhat enlarged but, unlike tuberculosis, there is little or no wasting. All movements are considerably limited. X-rays show diminution of the joint space with bone sclerosis and osteophytes; one or more loose bodies may be present.

TREATMENT

The osteoarthritis itself rarely requires treatment. Loose bodies, however, especially if they cause locking, should be removed; and if there are signs of ulnar neuritis, the nerve should be transposed.

FLAILNESS OF THE ELBOW

A flail elbow often causes surprisingly little disability, though a removable leather or polythene splint is usually helpful. There are three causes.

GUNSHOT WOUND — There is a scar, the elbow is completely flail, and often there is ulnar nerve palsy. X-rays show that the bones have been shot away.

CHARCOT'S DISEASE — There is complete flailness, but no scar and no ulnar palsy. The joint is enlarged and can be moved painlessly in any direction. X-rays show dislocation, bone destruction and calcification in the capsule.

POLIOMYELITIS — With a balanced paralysis the elbow may be flail, but flailness is not a presenting symptom.

OTHER DISORDERS OF THE ELBOW

TENNIS ELBOW

This is the commonest elbow disorder.

CAUSES

In most cases the cause is probably unrecognized trauma to the common extensor origin; subsequently, torn fibres adhere to untorn fibres and to the joint capsule.

extremes of elbow range are not often required. There are three common causes, described below.

POST-TRAUMATIC STIFFNESS

CAUSE

Temporary stiffness may follow any elbow injury. Permanent limitation of [illegible] the joint in adults, or when injury has [illegible]

SIGNS

Movement is limited but, unless the injury was recent, neither warmth nor tenderness can be felt. X-rays may show a fracture and occasionally a calcified shadow in front of the joint (myositis ossificans).

TREATMENT

To minimize post-traumatic stiffness, an injured elbow must be rested and passive movements absolutely prohibited. At the first suggestion of myositis ossificans, complete rest in a plaster gutter is imperative; later, when the calcified area has become small and discrete, it may be removed, though the gain in movement is not often great.

TUBERCULOSIS (*see also* page 27)

PATHOLOGY

Although the disease begins as synovitis or osteomyelitis, it is rarely seen until arthritis supervenes, by which time complete resolution cannot occur. Because the elbow is a superficial joint, a sinus is common.

SYMPTOMS

There is a long history with insidious onset of aching and stiffness.

SIGNS

Wasting is marked, especially of the biceps muscle and forearm flexors. While the disease is active the joint is held flexed, looks swollen, feels warm and diffusely tender; movement is considerably limited and accompanied by pain and spasm. X-rays show generalized rarefaction, and often an apparent increase of joint space because of bone erosion. With healing a little movement returns, but the arm always remains thin.

TREATMENT

In addition to general treatment (*see* page 25), the elbow is rested. At first, it may be held *in a plaster gutter flexed more acutely than a right angle and in mid-*rotation. Later a removable polythene splint, or collar and cuff, is sufficient and even these are sometimes discarded.

INJURY — A fracture or dislocation may break off a piece of bone into the joint. Osteochondritis dissecans, in which a piece of bone becomes detached from the capitellum, is possibly traumatic in origin.

DEGENERATION — In osteoarthritis small osteophytes may break off, and in Charcot's disease large pieces of bone are found in the joint.

INFLAMMATION — Small fibrinous loose bodies may occur in inflammatory disease, but the inflammatory process overshadows the loose bodies.

IDIOPATHIC — Synovial osteochondromatosis occasionally occurs, producing many loose bodies.

SYMPTOMS

There may be no symptoms. Sometimes the patient complains of sudden locking and unlocking of the joint. Later the symptoms of osteoarthritis may supervene.

SIGNS

The joint may be swollen. A loose body is rarely palpable. When degenerative changes have occurred, extremes of movement are limited. X-rays nearly always reveal the loose body or bodies; and in the special case of osteochondritis dissecans there is a rarefied cystic area in the capitellum and enlargement of the radial head.

TREATMENT

If loose bodies are troublesome they should be removed.

ULNAR NERVE LESIONS

Ulnar palsy is often the sequel to elbow disorders such as osteoarthritis, valgus deformity or constriction of the nerve by a fibrous band at the proximal end of the flexor carpi ulnaris muscle (ulnar tunnel). Occasionally the nerve repeatedly dislocates forwards.

There may be no pain. The usual presenting symptom is numbness or weakness in the hand. The hand becomes clawed and the interossei (especially the first) are wasted. The nerve may be tender in the region of the elbow.

The nerve may be freed by dividing the roof of the ulnar tunnel or, if necessary, by transposing it to the front of the elbow.

ULNAR NERVE TRANSPOSITION — The nerve is exposed by a long incision centred over the [illegible]

[illegible]

[illegible]

tion of the distal portion is facilitated by careful stripping of the branches. A bed is then prepared in the flexor muscles and, when the nerve can lie easily in it without tension, one or two catgut sutures are placed to hold the nerve in its new bed. The skin is then sutured. The arm is kept in a sling for 5 weeks.

BURSAE

The olecranon bursa sometimes becomes enlarged as a result of pressure or friction, and if the enlargement is a nuisance the fluid may be aspirated. Occasionally, the

Other possible, though unlikely, explanations include tendinitis and nipping of a synovial fringe.

SYMPTOMS

The onset is commonly gradual, rarely sudden, and hardly ever at tennis. The patient complains of pain on certain movements such as pouring out tea, turning a stiff door-handle or lifting with the forearm pronated. The pain in severe cases may radiate widely, distally or proximally.

SIGNS

The elbow looks normal and flexion and extension are full and painless (though extension is sometimes temporarily painful). The x-ray appearance is normal.

There are three positive physical signs, which exemplify those of any partial tear of muscle: (*a*) localized tenderness (over the lateral epicondyle); (*b*) pain on passive stretching (the wrist extensors are stretched by holding the elbow straight, the forearm prone and the wrist palmarflexed); and (*c*) pain on active contraction against resistance (the elbow is held straight and the forearm prone and the patient is prevented from dorsiflexing his wrist).

TREATMENT

The condition is self limiting and nearly always gets well, even without treatment, within a few months. Of the many methods of treatment, it is impossible to predict which is likely to be successful in any given case, and a useful sequence in which they may be tried is as follows.

(1) INJECTION — The tender area is injected with a mixture of 3 ml. of 1 per cent Xylocaine, 1 ampoule of hyaluronidase and 1 ml. of hydrocortisone acetate containing 25 mg. If the condition is improved, but not cured, the injection is repeated 3 weeks later.

(2) DEEP TRANSVERSE FRICTIONS TO THE TENDER AREA

(3) MANIPULATIONS

(4) REST — If the patient will submit to resting the arm in a sling or, better still, in plaster, for several weeks recovery is certain.

(5) OPERATION — *A few cases are sufficiently persistent or recurrent for operation to be* necessary. The origin of the common extensor muscle is detached from the lateral epicondyle.

GOLFER'S ELBOW

Golfer's elbow is a condition similar to tennis elbow, but the flexor origin from the medial epicondyle is the site of the lesion.

LOOSE BODIES

CAUSES

These resemble the causes of loose bodies in the knee.

CHAPTER 14

THE WRIST JOINT

EXAMINATION OF THE WRIST

SYMPTOMS

THE common symptoms are pain, deformity, swelling or a lump.

SIGNS

Examination of the wrist is not complete without also examining the elbow, forearm and hand.

LOOK — The skin is inspected for scars. Both wrists and forearms are compared to see if there is deformity. Swelling, lumps and wasting of the forearm are noted.

FEEL — Undue warmth is noted. Tender areas must be accurately localized, and the bony landmarks compared with those of the normal wrist. Lumps are palpated separately.

MOVE — Dorsiflexion and palmarflexion of the wrists are first compared. With the elbows at right angles and tucked in to the sides, radial and ulnar deviation are next examined, then pronation and supination.

X-RAY — Antero-posterior and lateral views are necessary, and often both wrists must be x-rayed for comparison. General rarefaction, alteration of joint spaces (in the radio-carpal or intercarpal joints) and abnormalities in shape or density of the individual bones are noted.

WRIST DEFORMITIES

CONGENITAL

ABSENCE OF THE RADIUS — Absence of the radius is rare; the whole or part of the bone may be missing. The carpus and hand are deviated laterally and often one or more fingers are missing.

MADELUNG'S DEFORMITY — This may be congenital in origin, but is probably due to injury affecting the lower radial epiphysis or rupturing the triangular fibrocartilage. The deformity (sometimes bilateral) is rarely seen before the age of 10 years and increases until growth is complete. The lower radius curves forwards, carrying with it the carpus and hand, but leaving the lower ulna sticking out as a lump on the back of the wrist. If deformity is severe the lower ulna may be excised, or osteotomy of the lower radius may be combined with shortening of the ulna.

bursa is affected by gout, syphilis or tuberculosis. A chronically enlarged bursa may need excision. In rheumatoid arthritis, also, the bursa may become enlarged, but more often a fibrous lump develops just distal to the olecranon process.

Suggestions for further reading

Brooks, D. M. (1950). Editorial: "Traumatic Ulnar Neuritis." *J. Bone Jt Surg.*, 32B, 291.
McGowan, A. J. (1950). "The Results of Transposition of the Ulnar Nerve for Traumatic Ulnar Neuritis." *J. Bone Jt Surg.*, 32B, 293.
[illegible] ochondritis Dissecans of the Elbow [illegible]
[illegible] Springfield; Thomas.
[illegible] "Surgery of Epicondylitis (Tennis [illegible]

necrosis of the proximal portion of a fractured scaphoid, and (*c*) avascular necrosis of the semilunar, either following trauma or without definite injury (Kienböck's disease; *see* page 42).

SYMPTOMS

There may have been injury in the past. Pain and stiffness occur at first intermittently after use. Later, they become more constant, and recurrent "wrist sprains" are common.

SIGNS

The appearance is usually normal and there is no wasting. Movements at the wrist and radio-ulnar joints are limited and painful. X-rays show irregular narrowing at the radio-carpal joint, with bone sclerosis; the proximal portion of the scaphoid or the semilunar may be irregular and dense.

TREATMENT

Rest, *in a removable polythene splint, is often sufficient.* Excision of the radial styloid process is helpful when osteoarthritis has followed scaphoid injury. Arthrodesis of the wrist is rarely necessary.

Note — *At the carpo-metacarpal joint of the thumb osteoarthritis is much commoner than* at the wrist, because the thumb is an "extreme-range joint" (*see* page 37), and the patient soon complains of pain on using the hand. It may follow trauma, but often there is no history of injury. The joint is tender, and full extension and adduction are painful. X-rays show narrowing of the space between the trapezium and first metacarpal bone, often with sclerosis. If short-wave diathermy and restriction of activity do not give relief, operation may be advisable. Arthroplasty (excision of the trapezium) gives relief of pain and often rapid return of full function; arthrodesis *always gives a good result, but involves 3 months* in plaster.

SWELLINGS AROUND THE WRIST

GANGLION

CAUSE

The cause of a ganglion is unknown. The history sometimes suggests that the lump is post-traumatic, but the high incidence of recurrence after operation is more characteristic of a benign neoplasm. Degeneration is an unlikely cause, because young people are commonly affected.

SYMPTOMS

The patient complains of a lump, *and occasionally of* pain or weakness.

SIGNS

The lump is translucent, cystic, not tender and often made *tense when the tendons* are put into action. Occasionally a small deep ganglion may compress a nerve or penetrate between its fibres, causing numbness or weakness.

POST-TRAUMATIC

After a Colles' fracture radial deviation and posterior angulation are common. These deformities cause little disability but may look ugly. Treatment (osteotomy) is rarely necessary.

POST-INFLAMMATORY

After long standing tuberculous or rheumatoid arthritis of the wrist forward subluxation at the radiocarpal joint commonly develops.

STIFFNESS OF THE WRIST

TUBERCULOSIS (*see also* page 27)

At the wrist, tuberculosis is rarely seen until it has progressed to a true arthritis.

SYMPTOMS

There is gradual onset of pain and stiffness, with weakness of the hand.

SIGNS

The forearm is wasted, the wrist swollen, the carpus subluxed forwards, and often there is a sinus. Movements are restricted and painful. The x-ray appearance is hazy, with narrowing and irregularity of the radiocarpal and intercarpal joints, and sometimes bone erosion.

DIFFERENTIAL DIAGNOSIS

The following conditions must be distinguished from tuberculosis:

RHEUMATOID ARTHRITIS (*see* page 19) — The wrist is a favourite site for rheumatoid arthritis but nearly always both wrists are affected (and often the knuckle joints).

MONARTICULAR ARTHRITIS — In middle life a monarticular arthritis of the wrist sometimes occurs which closely resembles tuberculosis, both clinically and radiologically. Biopsy, however, shows changes similar to rheumatoid arthritis, and sometimes other joints are affected later.

TREATMENT

In addition to the general treatment of tuberculosis, the wrist is rested in plaster which extends from the upper forearm to the proximal palm crease (permitting finger flexion) and holds the wrist 20 degrees dorsiflexed. Later a removable splint is used. Only rarely is arthrodesis necessary.

OSTEOARTHRITIS

CAUSES

The causes of osteoarthritis of the wrist are as follows: (*a*) fractures involving the wrist joint, especially an un-united fracture of the scaphoid; (*b*) avascular

SYMPTOMS

Pain is felt in the radial side of the wrist and thumb and is made worse by such actions as wringing clothes.

SIGNS

The condition is commonest in women aged 40–50 years. A small lump is visible on the radial side three-quarters of an inch above the wrist. The lump feels almost bony hard, so that it is frequently mistaken for an exostosis (but the x-ray appearance is always normal); tenderness is precisely localized to the lump. Pain is felt if the patient extends the thumb against resistance, or if it is passively adducted across the palm.

TREATMENT

Rest, transverse frictions or injections of hydrocortisone sometimes give relief. Operation, which consists of slitting the sheath, is uniformly successful and the patient wakes up cured.

Suggestions for further reading

Apley, A. G. (1956). "Tunnel Syndromes in the Upper Limb." *Practitioner*, **177**, 722.

Griffiths, D. L. (1952). "Tenosynovitis and Tenovaginitis." *Brit. med. J.*, **1**, 645.

TREATMENT

Squashing the lump may disperse it, but recurrence is common. If the lump is a nuisance it may be excised. A tourniquet is used and the ganglion dissected out carefully because many ganglia communicate with the capsule of the wrist joint. The cyst contains clear viscid fluid.

Note — Ganglia occasionally occur in the palm or fingers. They are then small, hard and tender, so that diagnosis is not easy until the lump is exposed.

COMPOUND PALMAR GANGLION

CAUSE

There is chronic inflammation of the common sheath of the flexor tendons, sometimes (by no means always) tuberculous. Infection may be blood borne or directly implanted.

PATHOLOGY

The synovial lining becomes thick and villous. The amount of fluid is increased and it may contain fibrin particles moulded by repeated movement to the shape of melon seeds. The tendons remain intact for some years, but eventually fray and may rupture.

SYMPTOMS

There is a gradual onset of swelling in front of the wrist and weakness of the hand. Occasionally there may also be paraesthesia due to median nerve compression, but pain is rare.

SIGNS

There may be evidence of tuberculosis elsewhere. There is an hour-glass swelling above and below the anterior carpal ligament, and fluid can be pushed from one part to the other (cross fluctuation); the swelling is neither warm nor tender.

TREATMENT

If the condition is tuberculous, general treatment is begun (*see* page 25). The contents of the ganglion are evacuated and replaced by streptomycin, and the wrist is rested in a splint. If these measures fail the entire flexor sheath is dissected out.

STENOSING TENOVAGINITIS (DE QUERVAIN'S DISEASE)

This is a tunnel syndrome (*see* page 9).

CAUSE

The fibrous sheath containing the extensor pollicis brevis and abductor pollicis longus tendons becomes thickened, possibly as a result of degenerative changes or overuse. There may be an underlying abnormality in the number or blood supply of the tendons.

NERVES (*see also* pages 96–98)

ULNAR PALSY — This may follow direct injury; less obvious is the trauma associated with long-standing valgus deformity or osteoarthritis of the elbow joint.

The ulnar two fingers are "clawed," each is hyperextended at the metacarpophalangeal joint and flexed at the proximal finger joint. The distal joint is straight if the lesion is high (because half the flexor profundus digitorum muscle is paralysed), but flexed if the lesion is low. The interosseus muscles are wasted, most noticeably in the first cleft. Ulnar sensation is lost.

OTHER NERVE LESIONS — Other nerve lesions may not produce obvious deformity, but the hand is held in an unnatural resting position.

Median nerve — With median nerve lesions, paralysis of the thenar muscles allows the thumb to fall into the simian position and the thenar eminence becomes flat; the index finger is held out straight because its profundus muscle is paralysed; sensation is lost over the median nerve area.

Musculospiral nerve — With musculospiral nerve lesions there is drop wrist; the fingers cannot be actively straightened at the metacarpophalangeal joints, but the interphalangeal joints can be extended with the lumbrical muscles.

Brachial plexus — Lesions of the brachial plexus or nerve roots may cause deformity, but neither the muscle weakness nor the sensory loss follows the pattern of a peripheral nerve lesion.

ARTERIES

ISCHAEMIC CONTRACTURE OF THE FOREARM (Volkmann, *see* page 266) — This lesion may follow damage to the brachial artery in elbow injuries. The forearm flexor muscles may subsequently fibrose and shrink. The forearm is thin, the knuckle joints hyperextended and all the finger joints flexed; the finger joints can be straightened only when the wrist is flexed.

ISCHAEMIC CONTRACTURE OF THE HAND (Bunnell; *see* page 267) — This may follow forearm injuries, especially when persistent swelling of the hand is associated with a tight plaster or bandage. The intrinsic hand muscles fibrose and shrink. The metacarpophalangeal joints are therefore flexed, the finger joints straight, and the thumb adducted across the palm.

TENDONS

MALLET FINGER — Mallet finger results from injury to the extensor tendon of the terminal phalanx. It occurs if the finger tip is forced bent during active extension, as in making a bed or catching a ball. The terminal joint is held considerably flexed and the patient cannot straighten it, though the surgeon can. The tendon insertion may have been avulsed or may have pulled off a triangular fragment of bone. The finger should be held in plaster from web to tip for 6 weeks, with the proximal joint flexed 90 degrees and the distal joint hyperextended. If only the terminal joint is held extended by strapping or a long thimble, the tendon joins in a lengthened position; however, the final result is not unsatisfactory and even untreated cases usually lose only the final 10 degrees of active extension.

CHAPTER 15

THE HAND

EXAMINATION OF THE HAND

SYMPTOMS

THE common symptoms in the hand are pain, paraesthesia, deformity, stiffness and weakness. Pain may be local or referred from a lesion in the neck, thoracobrachial junction, shoulder, elbow or wrist.

SIGNS

Both upper limbs must be bared for comparison.

LOOK — The skin may be scarred, altered in colour, unduly dry or sweating. Wasting and deformity, and the presence of any lumps should be noted. The position in which the fingers are naturally held is often important.

FEEL — The skin temperature and sensation should be tested, and any lumps palpated.

MOVE — Active movements are tested by examining the motor functions of the hand as pincers (as in writing); as a vice (as in holding a hammer); and for tapping (as in typewriting).

Individual finger and thumb movements must be examined when a nerve or tendon is suspect. Passive movements must be examined, especially if there is deformity.

X-RAYS — X-rays are necessary to exclude bony damage.

DEFORMITIES OF THE HAND

CONGENITAL DEFORMITIES

SYNDACTYLY (congenital webbing) — This condition may be corrected by separating the *fingers and repairing the defects with skin grafts*

LOBSTER HAND — This is usually familial. There is congenital absence of the middle three fingers. Function is usually good.

FLEXION OF THE FIFTH FINGER — This condition is often bilateral. The proximal finger joint is fixed flexed. Although it is congenital, the deformity is rarely seen until the child is aged 10 years. Function is good and the condition is best left untreated.

DEFORMITIES FOLLOWING TRAUMA

SKIN

CUTS — Cuts on the palmar surface are liable to heal with contracture; accordingly, *incisions should never cross skin creases.*

BURNS — Burns may heal with contracture and may then require excision and grafting.

develops. In the middle three fingers infection may for years be confined to a single finger, which is held flexed; its flexor sheath is swollen and fluctuant but not markedly tender. The normal x-ray appearance excludes chronic osteomyelitis. In addition to the general treatment of tuberculosis, aspiration of the sheath with the instillation of streptomycin is sometimes sufficient. Occasionally amputation is advisable.

From the thumb or fifth finger infection usually spreads to the common flexor sheath, producing a compound palmar ganglion (*see* page 138).

BONES

TUBERCULOUS OSTEOMYELITIS (DACTYLITIS) — This condition is rare but may occur in a metacarpal or phalanx. There is slight swelling and tenderness and often a sinus. X-rays show rarefaction, and ballooning of the affected bone. If general treatment and splintage fail, amputation of the affected finger or ray may be advisable.

JOINTS

RHEUMATOID ARTHRITIS (*see* Chapter 3) — Rheumatoid arthritis causes multiple deformities in both hands. The joints are knobbly and the muscles wasted. The metacarpophalangeal joints are fixed flexed and the fingers deviated to the ulnar side.

GOUT — Gout may involve the hands and, if there has been a number of attacks, joint deformities may follow. Usually the characteristic tophi can be seen.

OTHER DEFORMITIES

DUPUYTREN'S CONTRACTURE

CAUSE — The palmar fascia degenerates with age. In those individuals with an inherited predisposition, repeated minor trauma may cause small tears, which heal with fibrosis. Subsequent shrinkage of scar tissue predisposes to further tears, with progressive shrinkage. This hypothesis accounts for the age incidence (95 per cent of patients are aged over 40 years) and the familial tendency (10 per cent), but not for the fact that the contracture is commoner in non-manual workers.

PATHOLOGY — A fibrous plaque develops in the palmar fascia, usually opposite the ring finger. Histologically it contains torn collagen fibres and altered blood pigment. As the fascia thickens and shrinks, its forward prolongations pull the fingers into flexion and its superficial attachments pucker the palmar skin.

SYMPTOMS — In the early stage the patient may complain of pain on grasping; later the condition is painless but, as deformity increases, the grip is impaired, there is difficulty in releasing objects and the bent fingers get in the way.

SIGNS — Males and females are affected in a ratio of 10 to 1. Nearly always, both hands are affected, one more than the other. The ulnar palm is puckered, nodular and thick, with obvious fibrous bands. The affected fingers (chiefly the ring and little fingers) are flexed at the metacarpophalangeal and proximal finger joints; the distal joint is never flexed but may be hyperextended in severe deformities when the finger tips dig into the palm. Knuckle pads are sometimes seen.

TREATMENT — Physiotherapy, stretching, or vitamin E preparations are useless. Radiotherapy before and after operation has been recommended. Operation is indicated if

MALLET THUMB — Mallet thumb resembles mallet finger in that the terminal joint is held flexed and can only be straightened passively. The long thumb extensor may be cut anywhere, or it may rupture at the wrist in rheumatoid arthritis, following a fractured lower radius, *or in drummer boys. Except after an open cut, direct repair is not* advisable, for the ends are frayed. It is better to attach the cut distal end to another tendon (the short thumb extensor or the long radial extensor of the wrist).

BUTTONHOLE DEFORMITY — This follows division or avulsion of the central slip of the extensor tendon proximal to its insertion into the middle phalanx. The lateral slips separate and the joint buttonholes backwards, resulting in fixed flexion of the proximal joint and hyperextension of the distal joint. (If caused by a small cut on the dorsum the injury is often missed.) *Holding the finger straight in plaster probably leads to union,* but the finger must not be splinted straight for longer than 3 weeks. A more certain cure is effected by suturing the lateral slips together through a posterior incision.

REVERSED BUTTONHOLE DEFORMITY — This condition follows division or avulsion of the flexor sublimis tendon. The deformity is exactly the reverse of the familiar "buttonhole" deformity, in that the proximal joint is hyperextended and the distal joint slightly flexed. Attempted repair of an avulsed sublimis tendon produces adhesions which limit the action of the profundus; if there is disability or the retracted proximal end is tender, the sublimis tendon should be excised through a small palmar incision.

DIVISION OF PROFUNDUS TENDON — Division of the profundus tendon alone produces no obvious deformity, but the resting posture of the finger is straighter than normal; the terminal joint cannot be actively flexed. For treatment of a cut profundus tendon *see* pages 149 and 151; an avulsed profundus tendon should be reattached to the terminal phalanx.

DIVISION OF BOTH SUBLIMIS AND PROFUNDUS TENDONS — Division of both these tendons only follows open injuries (*see* page 148). There is no deformity but the finger is held straighter than normal and neither joint can be actively flexed; the patient may develop the trick of flexing the finger with its neighbour. Sometimes the retracted proximal ends of the tendons can be felt in the palm

BONES AND JOINTS (*see also* page 304)

FINGER STIFFNESS — This may follow undue splintage; no finger should ever be splinted straight, or for a day longer than necessary. Fractures into the finger joints, and joint sprains, are followed by painful stiffness and swelling which may last for many months, A mal-united fracture is an occasional cause of deformity but rarely impairs function.

DEFORMITIES FOLLOWING INFLAMMATIONS

TENDON SHEATHS

ACUTE INFECTION — This is liable to leave a *permanently stiff, bent finger.* If this is a nuisance, it should be amputated.

CHRONIC INFECTION — Chronic infection occasionally follows implantation of a low-grade pyogenic infection. Tuberculosis, however, is the commonest cause of chronic tenosynovitis; one of the finger-flexor sheaths may be infected by blood spread or direct implantation. A true synovitis *with thickening, fluid and fibrinous "melon seeds"*

pain which is relieved by moving the arm. During the day little pain is felt except with such activities as knitting. The pain may radiate up the arm. There is often clumsiness and difficulty in fine movements such as sewing.

SIGNS

Adults only are affected, women more commonly than men. Both hands, or only the master hand, may be involved. Abnormal physical signs are usually absent and indeed the condition should be diagnosed before signs are obvious. The pattern of sensory changes can sometimes be reproduced by arresting the circulation for 2 minutes with a pneumatic tourniquet, or by tapping the front of the wrist. The patient is often unsure of the precise distribution of pain, and it is helpful to ask her to return after a few days when she has mapped it out.

In late cases there is wasting of the thenar muscles with altered sensation in the median area.

DIFFERENTIAL DIAGNOSIS

Pain in the hand as a presenting symptom is usually due to a carpal tunnel syndrome. Two other conditions must be excluded.

CERVICAL SPONDYLOSIS — The pain is neither burning in character nor does it wake the patient; there are abnormal physical signs in the neck.

CERVICAL RIB SYNDROME — Wasting, when present, involves both thenar and hypothenar muscles because the first thoracic nerve is stretched.

TREATMENT

Treatment should not await the advent of obvious sensory loss or weakness for, once established, these may become permanent. As soon as the diagnosis is made, the anterior carpal ligament should be divided, and immediate cure results.

OPERATION — A small curved incision is made in the crease at the base of the thenar eminence. The ligament is identified and a small longitudinal incision made in it; through this a blunt guard is introduced to protect the nerve while the entire ligament is divided. For those unfamiliar with the operation a larger S-shaped incision is easier; it extends along the distal wrist crease with longitudinal prolongations at each end.

STENOSING TENOVAGINITIS OF FLEXOR TENDONS

CAUSE

There is insufficient space for normal tendon action. This may be due to thickening of the fibrous sheath (stenosing tenovaginitis) or to nodular thickening of the tendon. Occasionally the synovial sheath is villous.

SYMPTOMS

In adults any finger or the thumb may be affected, but the ring and middle fingers most commonly. The patient first notices that the finger clicks, often painfully, when he bends it. Later, he complains that when the hand is unclenched the affected

the deformity is a nuisance or rapidly progressing. The aim is reasonable, not complete, correction. After operation, a removable splint is used to maintain correction and is removed daily for wax baths and exercises. After 6 weeks it is used only as a night splint for a further 6 months. The following operations may be used.

Fasciotomy — A tenotome is inserted horizontally, the skin is carefully separated from the fascia and then deforming bands are divided. This manœuvre is repeated from other points of entry until reasonable correction has been obtained. In experienced hands this is a good operation.

Fasciectomy — Through an incision in the distal palmar crease the palmar fascia is carefully dissected free and excised. Where necessary, a Z-shaped incision over the proximal phalanx may be used in addition. This is the more popular operation but the results are no better than after fasciotomy.

Amputation — Amputation of a severely affected fifth finger is sometimes advisable, especially if the joint capsules have secondarily contracted.

MISCELLANEOUS CAUSES OF DEFORMITY

NEUROLOGICAL DISORDERS — Disorders such as syringomyelia, poliomyelitis, or tumours of the spinal cord or roots may cause a variety of hand deformities. Upper motor neurone disorders (hemiplegia or cerebral palsy) cause fixed flexion of the wrist and fingers with adduction of the thumb.

MYOPATHIES — Myopathies which affect peripheral muscles first and most severely (for example, peroneal muscle atrophy) may cause marked clawing of hands and feet. The forearm is thin, the metacarpophalangeal joints are hyperextended and the finger joints flexed. The thumb is abducted and flexed (this has been called an "intrinsic minus" hand and is easy to distinguish from ulnar nerve lesions because sensation is normal and all four limbs are involved).

MULTIPLE CHONDROMATA — These lesions may deform the hand considerably in Ollier's disease (*see* page 46). A single chondroma rarely presents as a deformity.

HYSTERICAL DEFORMITY — This condition should not be diagnosed until other causes have been excluded. The commonest hysterical deformity in the hand is flexion at the metacarpophalangeal joints, extended fingers and an adducted thumb.

TUNNEL SYNDROMES

CARPAL TUNNEL SYNDROME

CAUSE

In this condition there is insufficient space for the median nerve beneath the anterior carpal ligament. In the normal carpal tunnel there is barely space for all the tendons and the median nerve; consequently any swelling is likely to result in compression. Usually the cause eludes detection; the syndrome is certainly common in rheumatoid arthritis and occasionally follows bony injury.

SYMPTOMS

Pain and paraesthesia occur in the distribution of the median nerve in the hand. Typically the pain is worse at night; the patient wakes in the early hours with burning

DRAINAGE — Drainage is essential as soon as pus forms or its presence is suspected. A tourniquet and adequate anaesthesia are necessary. There are no standard incisions, but no incision should cross a skin crease. Nearly always the incision should be small and at the site of maximal tenderness. (With the use of antibiotics, the old-fashioned long incisions are hardly ever necessary.) When pus is encountered it must be carefully mopped away and a search made for deeper pockets of infection. It may be necessary to snip away necrotic skin. A drain is unnecessary, and only dry dressings are used.

REST AND ELEVATION — Rest and elevation are important in all hand infections. Once the acute inflammation has subsided, gentle active movements are begun.

INFECTIONS AT SPECIAL SITES

SUBCUTANEOUS TISSUES

NAIL BED (PARONYCHIA) — Infection beneath the horny layer of skin at the nail base or edge is common. The infected area is slightly swollen, red or purulent, and locally tender. Finger movements are full.

Unless discharge is already free, the nail bed must be elevated by blunt dissection. Small lateral incisions are sometimes advisable in addition. If pus has extended deeply, the overlying portion of nail is excised or the nail avulsed.

PULP (WHITLOW) — Pulp infection is common. Swelling is resisted by the fibrous bands connecting bone to skin, so that pain is severe and bone necrosis may occur. The finger tip is swollen, red and locally very tender. The patient guards the finger against contact; he is unwilling but able to move the finger.

Early drainage is essential. Under antibiotic cover a small incision over the site of maximal tenderness is usually sufficient, but the incision may need to be enlarged in late cases when the pus has extended. If healing is delayed X-rays may show a sequestrum which should be removed.

ELSEWHERE IN THE HAND — Anywhere in the hand a blister or superficial cut may become infected, causing local redness, swelling and tenderness. A local collection of pus should be drained through a small incision over the site of maximal tenderness. It is important to exclude a deeper pocket of pus.

Subcutaneous infection over the front of the middle phalanx carries the risk of involving a tendon sheath. Infection in a web space may also extend, usually along the lumbrical canal and thence either forwards through the palmar fascia or backwards between the metacarpal bones. In all these instances the importance of seeking a deeper pocket of pus is obvious.

Erysipeloid — Erysipeloid is a specific infection of one finger in meat or fish porters. It is rapidly cured by penicillin.

TENDON SHEATHS (SUPPURATIVE TENOSYNOVITIS)

Pus in a tendon sheath is uncommon but dangerous and painful. It is liable to leave a stiff finger because of synovial adhesions or because of thrombosis of the arterial supply to the tendons.

finger remains bent; it may suddenly straighten with a snap (trigger finger) or may remain flexed until forced straight with the other hand.

In babies only the thumb is affected and the mother notices that the thumb remains bent.

SIGNS

A tender nodule can be felt in front of the affected metacarpophalangeal joint, and the finger or thumb clicks when actively moved. In babies the nodule is hard and the thumb bent, and often dislocation is wrongly diagnosed.

TREATMENT

Through a transverse incision in the distal palmar crease, or in the metacarpophalangeal crease of the thumb, the fibrous sheath is incised until the tendon moves freely.

ACUTE INFECTIONS OF THE HAND

CAUSE

Almost invariably, staphylococci have been implanted by trivial or unobserved injury. Streptococcal infections occasionally occur and cause widespread disturbance.

SYMPTOMS

Usually there is a history of trauma, but it may have been so trivial as to pass unnoticed. A few hours or days later the finger becomes painful and swollen.

SIGNS

The patient may be ill and pyrexial.

LOOK — The finger may be red and swollen. Oedema of the dorsum of the hand is common in any infection Red streaks on the forearm indicate lymphangitis.

FEEL — Palpation must be gentle, but the site of maximal tenderness is important for diagnosis and treatment, and must be carefully pinpointed. Sometimes fluctuation can be elicited. Enlarged axillary lymph nodes may be palpable.

MOVE — With superficial infections the patient can move his finger, though he may be unwilling to do so. With deep infections the finger is immobile.

X-RAY — Severe pulp infections may lead to bone necrosis which is shown by x-ray.

TREATMENT

Superficial hand infections are common; if their treatment is delayed or inadequate, infection may rapidly extend, with serious consequences.

The essentials of treatment are as follows.

PENICILLIN — Penicillin must be given in large doses immediately a hand infection is seen, and suitable antibiotic therapy continued until there is healing.

FEEL — Sensation is tested to assess possible nerve injury.
MOVE — Active movements are tested to assess tendon damage.
X-RAY — Fractures, dislocations, or foreign bodies may be seen by x-ray.

PRIMARY OPERATION

Treatment has the same three objects as that of a compound fracture: (*a*) to minimize bacterial contamination by prophylactic antibiotics and skin preparation; (*b*) to prevent bacterial multiplication by excision of dead and devitalized tissue; and (*c*) to prevent fresh contamination by wound closure.

PREOPERATIVE PROCEDURES

(1) PROPHYLAXIS — Antibiotics, anti-tetanus serum and anti-gas-gangrene serum are given as soon as possible.

(2) ANAESTHETIC — General anaesthesia is preferable, though brachial block can be used, or even digital block for finger-tip injuries.

(3) TOURNIQUET — A high pneumatic tourniquet, applied after elevating the limb, is helpful but not essential. It should certainly not be used with crush injuries, where muscle viability is in doubt.

(4) CLEANING — The wound is covered with a sterile pack while the neighbouring skin is cleaned with cetrimide. More distant skin is scrubbed, shaved if necessary and painted with iodine in 90 per cent alcohol.

(5) POSITION — The hand must be placed on an arm table in a good light. The sterile pack is removed, the wound itself gently cleaned with cetrimide, and towelled off.

WOUND EXCISION AND DEEP REPAIR

SKIN — Do not excise a strip of skin around the wound—skin is too precious to waste. Usually the wound needs to be enlarged for adequate exposure; but enlarging incisions must not cross a skin crease, nor should they cross an interdigital web. Through the enlarged wound, loose débris is picked out.

MUSCLE — Muscle damage occurs only in the palm and mainly in the thenar and hypothenar eminences. Dead or doubtfully viable muscle is excised with meticulous care to avoid nerves.

TENDONS — Repair must not be attempted if the wound is grossly contaminated, or if the ends of the tendon can be found only by extensive dissection.

Extensor tendons are relatively easy and safe to repair, but with flexors the advisability of repair even in a clean cut depends upon the level of injury.

Proximal zone (from carpus to distal palmar crease) — Tendon suture is permissible and relatively easy because the cut ends do not retract far; the lumbrical muscle should be lightly stitched round the suture line of the profundus muscle.

Intermediate zone (distal palmar crease to proximal finger joint) — Here there are two tendons inside two sheaths (fibrous and synovial), and suture must not be attempted because adhesions inevitably result.

Distal zone — If the profundus tendon has been divided, primary suture is advisable unless the proximal end has retracted or the wound is dirty. If possible, the fibrous

MIDDLE THREE FINGERS — The affected finger is swollen and looks like a sausage. It is held bent, is very tender and the patient will not move it or permit it to be moved.

A small incision is made over the lateral aspect of the proximal phalanx; the infected sheath bulges into the incision, it is incised and penicillin instilled. If infection does not *rapidly subside, the old-fashioned incision must be used; this runs along the length of* the finger between palmar and dorsal creases (to avoid the digital nerve) and the sheath is laid open leaving at least one pulley intact. Delayed healing may be caused by necrosis of tendon, and if so the tendon should be removed or the finger amputated.

THUMB AND FIFTH FINGER — Tendon sheath infection in the thumb may spread to the radial bursa, and in the fifth finger to the ulnar bursa. The affected finger is swollen, bent, tender and held still, and swelling and tenderness extend proximally.

A small incision on one side of the proximal phalanx and the instillation of penicillin into the sheath are usually sufficient. If further drainage is necessary, the sheath should be more widely opened. If infection has extended into either bursa, a probe is inserted through the sheath and, where it emerges into the palm, a further incision is made.

FASCIAL SPACES

Infection from a web space or from an infected tendon sheath may spread to either of the deep fascial spaces of the palm.

MEDIAL SPACE (MIDPALMAR) — The palm is ballooned so that its normal concavity is lost. There is extensive tenderness and the whole hand is held still. For drainage an incision is made in the distal palmar crease and sinus forceps inserted on either side of the ring finger tendons, if the web space also is infected it should be incised.

LATERAL SPACE (THENAR) — The palm is flat, there is deep tenderness, and the thumb and index finger are held still. For drainage the skin is incised in the first web and the abscess opened with sinus forceps

PROXIMAL EXTENSIONS — From medial or lateral space infections, pus may track up the forearm where it can be drained by antero-medial or antero-lateral incisions.

MANAGEMENT OF OPEN INJURIES OF THE HAND

In the United States of America, where power machinery is extensively used, 2 million disabling work injuries occur each year, of which 75 per cent affect the hand. In England the problem is equally serious. Early and expert surgery is essential to minimize disability and shorten its duration; the care of the injured hand is not a job for a junior casualty officer.

SIGNS

Detailed examination may have to await exploration, but it is important to assess the damage as accurately as possible before operation, to avoid needless groping about in the wound solely for diagnostic purposes.

LOOK — Skin damage is the dominant factor. A clean cut is the least serious, though even with a tiny cut there may be damaged nerve or tendon. Irregular laceration or degloving is more serious, and crushed devitalized skin is the worst of all.

especially those which resemble the patient's normal job, until he is fit to start work; if necessary, his work is modified temporarily. Even if further surgery is required, tendon or nerve repair is postponed until the skin is healthy, there is no oedema, and the joints have regained a normal range of passive movement.

SECONDARY OPERATIONS

One of three procedures may be necessary: secondary repair or replacement of damaged structures, amputation of fingers, or reconstruction of a mutilated hand.

SECONDARY REPAIR

SKIN — If the skin cover has broken down or is unsuitable for surgery it is replaced by a graft. As always, the skin creases must be respected. Contractures are dealt with by Z-plasty or skin replacement.

TENDONS —

Proximal zone — If the tendons were not sutured at the primary operation, it is safe to carry out direct suture as a secondary procedure. The suture line of the profundus tendon is protected by wrapping the lumbrical muscle round it. The sublimis tendon may either be repaired or sacrificed.

Intermediate zone — If the sublimis tendon alone is cut and the proximal end forms an uncomfortable lump, it should be excised. A cut profundus tendon may be left if the patient is willing to accept the disability; otherwise a tendon graft is necessary.

Technique of tendon graft — Three donor sites can be used: (*a*) sublimis tendon from the injured finger (but this has no paratenon); (*b*) the fourth toe extensor (but this is rather thin, and the foot operation keeps the patient in bed); (*c*) palmaris longus tendon (the best) which must be excised with a wide margin of paratenon. It is absent in some people and its presence must be confirmed before operation.

The cut tendon is exposed by a longitudinal incision just behind the flexor finger creases, a transverse incision in the crease at the base of the finger, and a second transverse incision in the pulp. These enable a thick flap to be turned back.

The fibrous sheath is next excised, leaving a pulley opposite the proximal phalanx and one opposite the middle phalanx. Through a separate incision in the proximal palmar crease the sublimis tendon is excised and the profundus tendon trimmed. The graft is then sutured to the proximal profundus stump and the lumbrical muscle wrapped round the suture line. The graft is threaded through the pulleys and sutured to the distal profundus stump with the finger flexed.

The wounds are sutured, then dressed and splinted as after the primary operation. After 3 weeks, wax baths and gentle active exercises are begun.

Distal zone — Only the profundus tendon can have been cut. The disability of a flail [illegible] as described above, which is capable of restoring normal function but necessitates excision of an undamaged sublimis tendon, thus entailing a risk of leaving the finger worse than before operation.

NERVES — Cut median or ulnar nerves are repaired in the usual way. Digital nerves also are sutured if the finger has satisfactory motor function.

sheath is excised except for one band opposite the middle phalanx which is left as a pulley.

NERVES — These are left undisturbed unless the wound is fairly clean, when a single fine suture through the sheath helps in deciding the correct rotation at the secondary repair.

JOINTS — Suture of torn capsule and ligaments helps to restore stability and permit early movement.

BONES — Fractures are reduced and subsequently treated as described in Chapter 21. Occasionally, if the fracture is very unstable and the wound clean, internal fixation is employed. This is not devoid of risk but stiffness in the hand from prolonged external splintage is so disabling that the risk is worth taking.

Amputation — Amputation of a finger as a primary procedure should be avoided unless the damage involves many tissues and is clearly irreparable.

WOUND CLOSURE

HAEMOSTASIS — The tourniquet is removed and meticulous haemostasis obtained. The success of the operation depends largely upon this and skin healing.

SKIN CLOSURE — Only if the wound is grossly contaminated is closure delayed for a few days. Nearly always immediate closure is carried out by one of three methods.

Direct suture — This method is preferred if it can be achieved without tension and with only slight undercutting of skin edges.

Free skin grafts — These are often useful as temporary cover. They are usually taken from the front of the forearm and stitched into place. Partial thickness grafts take better, though it may be necessary later to replace them with full thickness grafts.

Flap grafts — Flap grafts are necessary if tendon or bare bone is exposed, for thin grafts do not take on these tissues. Flap grafts may be taken from local or distant sites. Thenar, palmar or cross-finger flaps are useful for amputated finger tips. Sometimes a severely mutilated finger is sacrificed and its skin used as a rotation flap. A skin-graft must be fixed securely and without dead space.

DRESSING — The wound is covered with several thicknesses of dry gauze, and ample wool soaked in flavine-paraffin emulsion. A firm crepe bandage ensures even pressure and, with a light plaster slab, holds the wrist and hand in the position of function. If possible, the finger tips are left visible.

POSTOPERATIVE PLAN

IMMEDIATE AFTERCARE — The hand is kept elevated and at rest. Antibiotics are continued as necessary. For the first 3 weeks the dressing is not disturbed unless the fingers become unduly swollen or blue or numb

ASSESSMENT — At 3 weeks the dressings are taken off. It is now possible to estimate, from the state of healing and a knowledge of the operative findings, what the future function of the hand is likely to be.

The sensory and the various motor functions (*see* page 140) are separately assessed. With this information, and a knowledge of the patient's work and hobbies, the nature of further treatment can be decided; it may be conservative (rehabilitation) or operative.

REHABILITATION — When the wound has healed, active exercises and wax baths are started. The hand is increasingly used for more and more arduous and complex tasks,

CHAPTER 16

THE NECK

SYMPTOMS

THE common symptoms of neck disorder are pain in the neck, scapular region or upper limbs; stiffness, either intermittent or constant; deformity, especially wry neck; and tingling, numbness or weakness in the upper limb. (Symptoms in both upper limbs usually indicate a neck disorder.)

SIGNS

No examination of the neck is complete without examination of both upper limbs.

LOOK — Any deformity is noted; the neck may be flexed forward, tilted sideways or twisted. From the back, skin blemishes or scapular abnormalities can be seen. One shoulder may be higher and there may be muscle wasting in the upper limb.

FEEL — The neck is palpated for tender areas or lumps. The radial pulses are examined and the skin tested for sensation.

MOVE — Forward flexion, extension, lateral flexion and rotation are tested, then shoulder movements. If necessary, muscle power and tone in the limbs are assessed.

X-RAY — In the lateral view, the cervical curve is inspected, then the individual vertebrae, the disc spaces and finally the intervertebral articulations An antero-posterior view of the lower cervical spine is rarely of value except to demonstrate a cervical rib; for the upper cervical spine, a projection through the mouth may be required. Occasionally, lateral films taken with the head alternately flexed and extended are required to demonstrate instability.

TORTICOLLIS

There are three distinct varieties of torticollis: foetal, infantile and secondary.

FOETAL TORTICOLLIS

The foetus has been lying awkwardly and the baby is born with torticollis, undue head moulding and a crumpled ear (Denis Browne). In this variety, called "postural" by Hulbert, there is never a sternomastoid "tumour". It always recovers spontaneously and no treatment is required.

INFANTILE TORTICOLLIS

CAUSE

The sternomastoid muscle, even at birth, is fibrosed and cannot elongate during growth. Deformity is not present at birth, but appears during infancy and increases. The cause of the fibrosis is unknown, and no explanation is convincing.

JOINTS — Joint stiffness is best treated by active exercises. Stiff knuckle joints are sometimes helped by capsulotomy. Flail joints are stabilized by tenodesis or arthrodesis.

BONES — Mal-union never requires treatment. Non-union is exceedingly rare, but grafting may be required.

AMPUTATION

INDICATIONS — A finger is amputated only if it remains painful or unhealed, or a nuisance (that is if the patient cannot flex it, or cannot straighten it or cannot feel with it) and then only if repair is impossible or uneconomic.

TECHNIQUE — A palmar flap is best and must always be ample in size; a tight flap usually gives pain. (Unless the flap seems too loose it is too tight.)

In the thumb, amputation must be carried out as far distally as possible, for every millimetre is worth preserving. Every effort should be made to avoid amputation of the thumb, for even a stiff or deformed thumb is worth keeping.

The index and fifth fingers are amputated as distally as possible, provided there is voluntary control of the proximal phalanx. If there is not, oblique amputation through the metacarpal shaft gives a good cosmetic result.

The middle and ring fingers should not be amputated through the knuckle joint, or the hand will be ugly and coins fall through it. If the proximal phalanx can be left, the hand is still ugly but stronger. Alternatively the entire finger with most of its metacarpal may be amputated; the hand is weakened but the amputation is less noticeable.

LATE RECONSTRUCTION

A severely mutilated hand should be dealt with by a hand expert. Three possibilities may be considered in exceptional cases.

(*a*) If all the fingers have been lost but the thumb is present, a new finger can sometimes be constructed with cancellous bone, covered by a tube flap of skin.

(*b*) If the thumb has been lost, a new one can be fashioned as above, or a finger can be rotated to oppose the other fingers.

(*c*) If the thumb and all the fingers have been lost, making a cleft between two metacarpal bones may permit pincer action.

Suggestions for further reading

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[illegible] . *scand*, 96, Supp. 139.

Subcutaneous tenotomy at the lower end—This must be carefully performed if the vessels are to be avoided, but leaves no visible scar—an important consideration in an operation which is performed only for cosmetic reasons.
Open division of the lower end—A transverse incision is used, and the tendon divided. The anaesthetist then twists the child's head so as to obtain further correction of the deformity, and tight fascial bands are divided; this must be repeated until complete overcorrection is achieved. The operation is completely safe and the scar hardly visible.
Division of the upper end—This procedure may be performed alone, or may be combined with either of the above methods, the advantage being that the scar is hidden by the hair.

After operation correction must be maintained by a skull cap tied under the axilla. This is worn for several months until the child has learnt to hold his head correctly.

SECONDARY TORTICOLLIS

A tilt or twist of the neck may develop secondarily as a result of acute disc prolapse (the commonest cause in adults), so-called fibrositis (usually a prolapsed cervical disc), skin scarring (especially after burns), inflamed neck glands, vertebral tuberculosis, or injuries of the cervical spine. In all these the diagnosis is usually obvious; the condition does not necessarily date from infancy and there is no facial asymmetry.

"Spasmodic" torticollis is also a secondary deformity, and is associated with psychological disorder. The sternomastoid muscle is in marked spasm, and the head grossly twisted. Sometimes violent jerking movements occur or are provoked by attempted correction.

The treatment of secondary torticollis is that of the primary cause.

PROLAPSED CERVICAL DISC

CAUSE

The factors responsible for a prolapsed cervical disc are the same as those of lumbar disc prolapse, namely injury (especially sudden unguarded movements), absorption of fluid causing nuclear tension to increase, and degenerative changes in the annulus (*see* page 178).

PATHOLOGY

Prolapsed material may press on (*a*) the dura mater, causing neck pain and stiffness; or (*b*) the nerve roots, causing pain and paraesthesia in one or both arms. Prolapse occurs immediately above or below the sixth cervical vertebra, so that the nerve roots affected are C.6 or C.7.

SYMPTOMS

The original attack, unlike that of lumbar disc prolapse, can seldom be related to definite and severe strain. It often occurs when a patient stretches himself on waking.

Subsequent attacks may be sudden or gradual in onset, and with trivial cause. In each, the patient may complain of the following symptoms.

TEAR — The sternomastoid muscle might conceivably be torn during birth, and the haematoma subsequently fibrose. A history of difficult labour is in fact common, and a lump (sternomastoid "tumour") appears; but the lump is too discrete to be a haematoma, and microscopically contains no haemosiderin.

ISCHAEMIA — The sternomastoid arteries might be obstructed during labour, with subsequent fibrosis; but microscopically the lesion is quite unlike Volkmann's ischaemic fibrosis. Moreover, a labour in which the head had been twisted long enough to produce ischaemic contracture would probably be lethal to the baby.

OTHER THEORIES — Venous thrombosis and infective myositis have been blamed, but with little evidence.

SYMPTOMS

A history of difficult labour or breech delivery is common. In only 20 per cent of cases is a tumour noticed at between 1 and 4 weeks; it disappears within a few months. *Deformity, the main symptom, may not be sufficiently obvious to attract* attention before the age of 3 years.

SIGNS

If infantile torticollis is seen in the first few weeks of life, often the only sign is a lump which is large and discrete and involves one or both heads of the sternomastoid muscle. There may be neither facial asymmetry nor obvious limitation of movement, though even at this early age the baby may hold his head over to one side. Frequently the child is not seen in an orthopaedic clinic until he is 3–4 years old, by which time there is no tumour and the neck signs are as follows.

LOOK — The head is tilted, with the ear on the affected side lower and more forward. The face on the affected side becomes shorter and wider.

FEEL — The sternomastoid tendon feels tight but the belly of the muscle is soft.

MOVE — Movements are full in the direction of the deformity and are limited in the opposite direction.

X-RAY — This is necessary to exclude congenital anomalies of the vertebrae.

TREATMENT

PROPHYLAXIS — If a child has had a sternomastoid "tumour" every effort should be made to prevent torticollis from developing. Each day a physiotherapist or the mother manipulates the neck into a position which elongates the affected sternomastoid to the full. The baby is laid to sleep on alternate sides.

STRETCHING AND SPLINTAGE — If, when the child is first seen, the head cannot be tilted fully in the direction opposite to that of the deformity, daily stretching is followed by the application of a splint or a linen skull-cap attached by tapes tied under the axilla. This treatment is continued until the child naturally comes to hold its head correctly and the cap is worn at night for a further 6 months at least. A careful watch is kept for recurrence of the deformity.

OPERATIONS — One of three procedures designed to elongate the sternomastoid is indicated if stretching fails or the deformity is not seen until the age of 3–4 years.

Subcutaneous tenotomy at the lower end — This must be carefully performed if the vessels are to be avoided, but leaves no visible scar—an important consideration in an operation which is performed only for cosmetic reasons.
Open division of the lower end — A transverse incision is used, and the tendon divided. The anaesthetist then twists the child's head so as to obtain further correction of the deformity, and tight fascial bands are divided; this must be repeated until complete overcorrection is achieved. The operation is completely safe and the scar hardly visible.
Division of the upper end — This procedure may be performed alone, or may be combined with either of the above methods, the advantage being that the scar is hidden by the hair.

After operation correction must be maintained by a skull cap tied under the axilla. This is worn for several months until the child has learnt to hold his head correctly.

SECONDARY TORTICOLLIS

A tilt or twist of the neck may develop secondarily as a result of acute disc prolapse (the commonest cause in adults), so-called fibrositis (usually a prolapsed cervical disc), skin scarring (especially after burns), inflamed neck glands, vertebral tuberculosis, or injuries of the cervical spine. In all these the diagnosis is usually obvious; the condition does not necessarily date from infancy and there is no facial asymmetry.

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Subsequent attacks may be sudden or gradual in onset, and with trivial cause. In each, the patient may complain of the following symptoms.

(*a*) Pain and stiffness of the neck; the pain often radiates to the scapular region and sometimes to the occiput.

(*b*) Pain and paraesthesia in one upper limb (rarely both), often radiating to the outer elbow, back of the wrist and to the index and middle fingers. Weakness is rare.

Between attacks the patient feels well.

GENERAL SIGNS

There are no general signs and the patient is a fit adult.

NECK SIGNS (DURING AN ATTACK)

LOOK — The neck may be tilted forwards and may also be tilted sideways.

FEEL — Tender areas are felt in the posterior neck muscles, the trapezius and the scapular region.

MOVE — Some movements are restricted and painful, but at least one movement is full and painless, unless the attack is very severe. Shoulder movements are full.

X-RAY — At the affected level the normal lordosis is interrupted and the disc space is often narrowed.

ARM SIGNS

There may be evidence of neurological disturbance, as follows.

Root stretching, by pulling the neck and arm away from each other, may increase the symptoms.

Sensation may be diminished in the thumb and index (C.6) or middle finger (C.7).

Motor weakness is rare, but may be detected in the triceps muscle or in the forearm flexors or extensors.

Reflexes are usually normal, but the triceps jerk may be reduced.

DIFFERENTIAL DIAGNOSIS

The following conditions must be distinguished from cervical disc prolapse.

CERVICAL RIB SYNDROME — Pain is felt usually in the ulnar forearm and hand, a lump may be palpable in the neck and the rib may show on x-ray.

CARPAL TUNNEL SYNDROME — Although pain may be referred up to the neck, neck movements are painless, and the pain in the hand is felt on the palmar surface in the distribution of the median nerve.

SUPRASPINATUS TENDON LESIONS — Although the distribution of pain may resemble that of a prolapsed cervical disc, movements at the shoulder joint are abnormal.

CERVICAL TUMOURS — With tumours of the spinal cord, nerve roots or cervical lymph nodes, the symptoms are not intermittent and the x-ray picture may be abnormal. Tumours of the cervical vertebrae are seen on x-ray.

CERVICAL SPINE TUBERCULOSIS — The symptoms do not occur in attacks, there may be an abscess, and x-rays show narrowing of a disc space, also bone destruction.

TREATMENT

Heat and analgesics are soothing but, as with lumbar disc prolapse, there are only three satisfactory ways of treating the prolapse itself.

REST — A collar is comforting and prevents unguarded movement; it may be made of cardboard and felt, stiff sponge-rubber or polythene.

REDUCE — Traction may enlarge the disc space, thus permitting the disc to slip back into place. The head of the couch is raised and weights tied to a harness fitting under the chin and occiput. Up to 40 pounds may be used for 20 minutes daily. Continuous traction using up to 10 pounds for 48 hours is more effective but the patient must be in hospital and sedated. Rapid reduction by manipulation (without anaesthetic) can be effective, and is probably safe providing the neck is first pulled in the extended position.

REMOVE — Cervical laminectomy with removal of a disc is rarely necessary. This is fortunate, because the operation is difficult and dangerous. If symptoms are severe enough for operation, laminectomy alone, without attempting to see and remove the disc, probably affords sufficient decompression.

CERVICAL SPONDYLOSIS

PATHOLOGY

Disc degeneration occurs in the lower cervical spine. Disc material extrudes, it may fibrose, and the fibrosis may spread to the root sleeves; at the edges of the vertebrae it may calcify, producing lipping. Osteoarthritic changes develop in the intervertebral joints.

SYMPTOMS

Pain in the neck and scapular region often comes on gradually, and may radiate down the upper limbs. Paraesthesia may also occur.

Occasionally there is weakness of the hand. Very rarely pressure on the cord produces paraesthesia, weakness or clumsiness of the lower limbs.

SIGNS

The patient is aged over 40 years and is otherwise fit.

LOOK — The appearance is normal.

FEEL — Tenderness in the posterior neck muscles and scapular region is common.

MOVE — All movements are slightly limited by pain at their extremes.

X-RAY — Several disc spaces are diminished, and the corners of the vertebrae show lipping. (Identical x-ray changes may be present in a patient with no symptoms.)

NOTE — In the upper limb (or limbs) there are occasionally sensory changes and possibly weakness. Rarely, in the lower limbs, there is weakness of upper motor neurone type, with spasticity and increased jerks. Spondylosis may be complicated by an acute disc prolapse.

TREATMENT

Heat and massage are often soothing, but restricting neck movements in a collar is the most effective treatment.

Operation is very rarely indicated. If severe symptoms are relieved only by a rigid

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TREATMENT

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(c) weakness of the hand and clumsiness in performing fine actions. Symptoms of a true Raynaud's phenomenon are very rare.

NECK SIGNS

LOOK — The shoulder on the affected side may be lower.

FEEL — A lump (the abnormally elevated subclavian artery) may be palpable above the clavicle. It pulsates, is tender, and pressure on it may increase symptoms.

MOVE — Neck and shoulder movements are normal, but pulling the arm downwards while pushing or twisting the neck away may obliterate the pulse. (This phenomenon is commonly demonstrable in normal people.)

X-RAY — Often the x-ray appearance is normal. Occasionally a well-formed rib is seen, but more often there is merely enlargement of the transverse process of the seventh cervical vertebra.

ARM SIGNS

LOOK — The small muscles of the hand may be wasted: thenar, hypothenar and interosseus muscles are affected because all are supplied by the first thoracic nerve. Occasionally increased sweating or cyanosis is seen.

FEEL — If there are sensory changes they occur in the distribution of the first thoracic nerve root and are not confined to the distribution of a single peripheral nerve.

MOVE — If there is wasting muscle power is reduced.

DIFFERENTIAL DIAGNOSIS

Many disorders resemble cervical rib syndrome.

CARPAL TUNNEL SYNDROME — This condition is common, whereas cervical rib syndrome is rare; the two disorders are frequently confused In carpal tunnel syndrome the pain is worse at night, wakes the patient from sleep, and the fifth finger is unaffected. Any weakness is purely thenar, and the x-ray appearance is normal. Even when x-rays show a cervical rib, the patient's symptoms may still be due to carpal tunnel compression and the rib should not be incriminated unless all groups of intrinsic muscles are wasted or vascular disturbances are demonstrated.

ULNAR TUNNEL SYNDROME — The symptoms and signs are sharply confined to the distribution of the ulnar nerve, and the neck is unaffected.

ACROPARAESTHESIA — There is sensory disturbance in both hands and sometimes the feet. When only the hands are affected the diagnosis is usually wrong, and the patient is probably suffering from a carpal tunnel syndrome.

PANCOAST SYNDROME — Apical carcinoma of the bronchus may infiltrate the structures at the root of the neck, causing pain, numbness and weakness of the hand. A hard mass may be palpable in the neck and x-ray of the chest shows a characteristic opacity.

CERVICAL SPINE LESIONS — In disc prolapse or spondylosis, pain is not postaxial in distribution and neck movements are limited. In tuberculosis and secondary deposits the x-ray appearance is characteristic.

and irksome support, spinal fusion is valuable. Very rarely, when abnormal signs in upper and lower limbs are not abolished by splintage or traction, decompression by laminectomy is performed.

CERVICAL RIB SYNDROME

CAUSE

With the arm at the side, the subclavian artery and first thoracic nerve normally describe a hairpin bend where they pass through the triangle bordered by the first rib, scalenus anticus and scalenus medius muscles. In this situation they are liable to be compressed or stretched and their vulnerability may be caused or increased by any of the following factors.

CONGENITAL ABNORMALITIES —

Extra rib — An extra rib may extend from the seventh cervical costal process. Sometimes the process is merely enlarged or a fibrous "rib" is present. In either case, the neurovascular bundle "climbs" over it.

Extra scalene muscle — An additional scalene muscle may be present, or the insertions of scalenus anticus and medius may be too closely approximated.

Angulation of first thoracic nerve — The brachial plexus may be postfixed so that, even when the rib and muscles are normal, the first thoracic nerve is too acutely angulated.

ACQUIRED FACTORS —

Age — With declining youth and increasing obesity the shoulder may sag, exaggerating the hairpin bend of the artery and nerve.

Posture — Bracing the shoulder has been alleged to compress the neurovascular bundle between rib and clavicle.

PATHOLOGY

NERVES — The first thoracic nerve (occasionally the lower trunk) is stretched or compressed causing sensory changes along the postaxial forearm and hand and weakness of the intrinsic hand muscles.

ARTERY — The subclavian artery is rarely compressed but its wall may be traumatized, leading to the formation of small emboli. Other possible causes of arterial disturbance are paralysis of the sympathetic fibres contained in the lower trunk, irritation of the periarterial sympathetic fibres, or compression of the axilliary artery between the heads of a stretched median nerve.

Obvious vascular disturbance is uncommon but may result in paraesthesia of the hand, cramping pain, sweating, cyanosis or occasionally finger-tip necrosis and Raynaud's phenomenon.

SYMPTOMS

There are no general symptoms or neck symptoms. Those in the upper limb come on gradually, nearly always in females aged over 30 years, and are as follows: (*a*) pain in the ulnar hand and forearm and sometimes in the scapula, often worse after carrying a shopping basket; (*b*) tingling and numbness in the hand; and

CHAPTER 17

THE THORACOLUMBAR SPINE

EXAMINATION

SYMPTOMS

THE most common presenting symptoms of thoracolumbar spine disorders are pain, deformity, a lump, and paraesthesia or weakness of the legs (the effects of nerve root pressure). Stiffness is occasionally complained of.

SIGNS WITH PATIENT STANDING

LOOK —

Skin — Scars, abnormal hair or pigmentation may be seen.

Shape and position — From behind, any asymmetry of the chest, trunk, pelvis or hips is noted and any lumps are observed. If the spine is deviated from the midline or rotated, there is scoliosis. (Minor degrees of scoliosis are best seen with the patient bending forwards; but in this position a postural scoliosis disappears.)

From the side, any abnormalities of the antero-posterior curves are seen. The thoracic spine may be unduly bent (kyphosis) or angulated forwards (kyphos, which shows clearly as a knuckle when the patient bends). The lumbar spine may be unduly flat or excessively lordosed.

FEEL —

Warmth is not detectable and tenderness is only occasionally useful. The spinous processes should be palpated, noting any kyphos or a "step".

MOVE —

Lumbar spine movements are examined as follows.

Forward flexion is tested by watching the patient try to touch his toes. Even with a stiff lumbar spine the patient may be able to touch his toes by bending at the hips, so while the patient bends the lumbar spine is observed. Extension is tested by asking the patient to lean backwards; again the lumbar spine is watched. Lateral flexion is tested by asking the patient to bend sideways, sliding his hand down the outer side of his leg. Rotation (of little importance) is examined by asking the patient to look alternately over each shoulder

Examination of thoracic spine movements is of little value, but the respiratory excursion should be noted.

SIGNS WITH PATIENT LYING ON HIS BACK

It is important to examine for (*a*) an abscess (a psoas abscess may be visible and feel fluctuant); (*b*) fixed deformity of the hips; (*c*) cord or root involvement.

SPINAL CORD LESIONS — Syringomyelia or other spinal cord lesions may cause wasting of the hand, but other distinctive neurological features establish the diagnosis (*see* page 172).

CUFF LESIONS — With supraspinatus tendon lesions pain sometimes radiates to the arm and hand but shoulder movement is limited and painful.

TREATMENT

CONSERVATIVE — The patient is taught exercises to strengthen the shrugging muscles. She is given analgesics, and advised to reduce her own weight and that of her shopping basket. These measures are usually adequate.

OPERATIVE — Operation is indicated if pain is severe, if muscle wasting is obvious, or if there are vascular disturbances.

Technique — The neurovascular bundle is exposed through a transverse incision half an inch above the clavicle. The scalenus anticus muscle is identified, the phrenic nerve retracted and the cause for the compression or stretching sought. Some surgeons content themselves with dividing the scalenus anticus muscle, excising a rib or cutting a tight fibrous band, but it is wiser in every case to cut all three sides of the triangle; that is, to divide the scalenus anticus and medius muscles, and excise a cervical rib or fibrous band; if no rib or band is present a portion of the first rib is excised.

TUBERCULOSIS OF THE CERVICAL SPINE
(*See also* page 171)

Cervical spine tuberculosis is very rare. The presenting symptoms may vary from trivial neck pain to tetraplegia. Deformity is usually slight, though the normal cervical lordosis may be lost and there may be torticollis. Movements are limited, provoking pain and spasm when attempted. X-rays usually show bone destruction with a narrowed disc space and forward angulation. If there is an abscess it may be retropharyngeal, or present behind the sternomastoid muscle.

General treatment is essential (*see* page 25). The patient is treated on a plaster bed and a band of leather or plaster around the forehead is attached to the plaster bed to hold the head still. With healing, the patient is allowed up wearing a support which includes the forehead. Bone grafting may be advisable.

Suggestions for further reading

Brai
Fryk
Griff

usually have no symptoms or signs referable to the spina bifida. By custom, however, the term "occulta" is used when there is no visible cystic lump.

PATHOLOGY

There is localized failure of fusion of the two halves of the neural arch. In the gap is a fibrous band (membrana reuniens) attached to the skin and dimpling it, and attached to the cord, so preventing its normal recession with growth.

SYMPTOMS

These include (*a*) a clump of hair, naevus or pad of fat; (*b*) bladder dysfunction, especially bedwetting; (*c*) leg symptoms—deformity, shortening, weakness, anaesthesia or trophic changes may affect one or both legs. Bladder and leg symptoms may appear, or increase, between the ages of 10 and 14 years.

SIGNS IN THE BACK

LOOK — A dimple or a hamartoma (for instance, a naevus or clump of hair) may be visible in the midline of the back.

FEEL — The bony defect may be palpable.

MOVE — Usually there is no gross abnormality of movement.

X-RAY — The gap in the laminae is best seen in an antero-posterior view. Often other abnormalities are also present.

SIGNS IN THE LEGS

LOOK — One or both legs may be thin, deformed or short. There may be trophic changes.

FEEL — The skin feels cold and has diminished sensation.

MOVE — Weakness, paralysis or fixed deformity may be present.

DIFFERENTIAL DIAGNOSIS

A spina bifida may present with club feet. In isolated congenital talipes, however, skin sensation is normal and there are no abnormal signs in the back.

Diastematomyelia is a condition in which the cord is bifurcated by a spur of bone (or cartilage) growing from the back of a vertebral body. The child may present with a limp and abnormal signs in one or both lower limbs. Like those of spina bifida (with which the condition may coexist), these signs are liable to present during a period of rapid growth. On x-ray, however, the spur can usually be seen, and the vertebral bodies are widened. A myelogram will confirm or refute the diagnosis.

TREATMENT

BACK — If symptoms are increasing at the age of 10–14 years, division of the membrana reuniens may be advisable.

LEGS — Anaesthetic skin requires careful toilet and attention to footwear. A flail limb may need splintage. Foot deformities can be treated by operative correction; but great care is necessary in applying plaster, for anaesthetic skin ulcerates without warning.

Muscle tone and power is examined, sensory changes noted and the reflexes tested. It is important to test for low lumbar root involvement. The straight legs are lifted alternately. If straight-leg raising is limited by pain, the leg is lowered 2 degrees from the painful angle; if dorsiflexing the foot or bending the neck forwards causes pain to return, the limitation of straight-leg raising was due to abnormal stretching of the sciatic nerve or its roots and other causes are excluded.

SIGNS WITH PATIENT LYING ON HIS FACE

The presence of any deformity or abscess is confirmed. The tone and bulk of the back and buttock muscles are examined and the hips tested for full extension.

SACROILIAC JOINTS — The sacroiliac joints are difficult to examine because they are too deep to feel and because it is almost impossible to be sure that movement is not occurring at the lumbar spine or hips. The iliac crests may be squeezed together, pushed apart or, with the patient lying on either side, rotation may be attempted. If any of these movements is painful, the sacroiliac joint may be at fault.

X-RAY APPEARANCES

Antero-posterior, lateral and (rarely) oblique views are required and are examined as follows.

THE SPINE AS A WHOLE —
Shape — In the antero-posterior view any tilt or scoliosis and any undue widening of the vertebral canal are noted; in the lateral view, any abnormal kyphosis or lordosis is seen.
Density — General rarefaction is sometimes obvious.

VERTEBRAL BODIES —
Position — Forward shift (spondylolisthesis) should be noted.
Shape — A vertebral body should appear like a box with four straight sides; each border is examined for interruption, indentation, erosion or ballooning.
Architecture and density — A single vertebral body may be too dense, too rare, may contain a local area of rarefaction, or may be abnormal in architecture.

OTHER FEATURES —
The disc spaces may be diminished or ballooned; there may be a gap in the laminae. The intervertebral joints may be displaced or narrowed. There may be calcification in ligaments or other soft tissues.

CONGENITAL ANOMALIES

Congenital anomalies of the spine include (*a*) spina bifida (occulta or manifesta); (*b*) congenital wedged vertebra (*see* "Scoliosis"); (*c*) fusion of vertebrae (usually cervical, and unnoticed unless associated with Sprengel's shoulder or Klippel-Feil syndrome); (*d*) sacralization of the fifth lumbar vertebra or a transitional vertebra (probably not a source of symptoms).

SPINA BIFIDA OCCULTA

The term "occulta" means "secret" or "hidden", and should strictly be reserved for those cases in which the abnormality is found only by x-ray. Such patients

paraplegia), or escape into the soft tissues as a cold abscess. As the disease progresses, destruction, wedging and forward angulation increase and may become severe, especially in children.

HEALING — With healing, the bones recalcify and harden and sometimes an abscess may calcify. Spontaneous bony fusion may occur between vertebrae. Nevertheless, if there has been much forward angulation, the spine is usually "unsound", and flares are common, with further illness and further collapse.

SYMPTOMS

There is a long history with insidious onset and vague ill health. Pain is usually slight, often only a dull ache, worse after standing, sitting or jolting. Sometimes a lump (the kyphos) is the presenting symptom, or occasionally paraesthesia or weakness of the legs due to paraplegia. With healing, pain disappears, but deformity persists.

SIGNS IN ACTIVE STAGE

The general signs of tuberculosis have already been described (*see* page 24). The local signs are as follows.

LOOK — A characteristic and almost constant feature is an angular kyphos, best seen from the side with the patient bending forwards. With advanced disease there is gross kyphosis and kyphos, so that the patient has a hunched back.

FEEL — The kyphos, even if slight, is easily felt by running a hand along the spinous processes. Tenderness is slight or absent.

MOVE — Diminished movement cannot be detected in the thoracic spine. (It is important always to feel and move the legs to detect paraplegia.)

X-RAY — In the lateral view two neighbouring bodies show areas of destruction and the intervening disc is narrowed. One or both bodies are usually wedged (narrower in front) and there is forward angulation. The antero-posterior view in many cases shows a paravertebral abscess. These features are diagnostic.

HEALING STAGE

The patient's general condition is satisfactory but deformity remains. X-rays show recalcification of the bones and sometimes abscesses calcify.

AFTERMATH

The infection is always liable to flare up, especially when the disease affects the lower thoracic spine and if there is much angulation.

DIFFERENTIAL DIAGNOSIS

Tuberculosis of the thoracic spine must be distinguished from other causes of backache and increased forward curve.

IN CHILDREN — Tuberculosis is almost the only cause of backache with deformity (kyphos) in children. Calvé's disease, which is very rare, also presents with pain and kyphos; x-rays show that one vertebral body is collapsed, neighbouring disc spaces being normal in width.

SPINA BIFIDA MANIFESTA (CYSTICA)

PATHOLOGY

As in spina bifida occulta, the two halves of the lamina fail to fuse, but there is also a visible lump which may be one of the following:

MENINGOCELE — A sac of dura and cerebrospinal fluid herniates through the fibrous membrane, stretching over the cord.

MYELOMENINGOCELE — The cord and roots lie outside the vertebral canal and are stuck to the meningeal sac.

SYRINGOMENINGOMYELOCELE — In addition to a myelomeningocele, there is inflation of the central canal of the cord.

CLINICAL FEATURES

In the midline of the back there is a lump which is cystic and translucent, and which fluctuates with crying. The skin over it is liable to ulcerate.

Bladder disturbances are usual and there may be associated hydrocephalus due to the Arnold-Chiari malformation of the brain. If the child survives, the limbs may be affected, as in spina bifida occulta.

TREATMENT

It may be possible to excise the sac and repair the defect in muscle and skin. Operation should be performed in early infancy, but is contraindicated by any of the following: paralysis of legs; loss of sensation in legs; loss of sphincter control of bowels or bladder; associated hydrocephalus or other severe malformations.

TUBERCULOSIS

The highest incidence of spinal tuberculosis is between the ages of 20 and 30 years, though it may occur at any age. It is convenient to describe tuberculosis of the thoracic and lumbar spine separately.

TUBERCULOSIS OF THE THORACIC SPINE

PATHOLOGY

OSTEOMYELITIS — Spinal tuberculosis is essentially an osteomyelitis. Blood-borne infection settles in a single vertebral body, part of which is destroyed and replaced by necrotic caseous material. The bone collapses because it is necrotic and soft It squashes down into the body below, which is also soft, and infects it. This is the likeliest explanation of the fact that, even in early disease, two adjacent vertebral bodies are usually affected and the intervening disc space narrowed, it is unlikely that the tuberculous process could begin in the disc itself, which is avascular.

KYPHOS — An angular kyphos develops at the level of the disease because collapse is limited to the front of the bodies, the back being held by the unaffected neural arches.

SPREAD — The collapse squeezes out infected caseous material which may infect neighbouring vertebrae (causing increasing forward collapse), or press on the cord (causing

essential, nor does it always "take", but it has two advantages: (*a*) if the graft takes, it provides a splint which the patient cannot remove; and (*b*) after a bone graft the necessary minimum of a further 6 months' recumbency in plaster is readily accepted by the patient and the longer his back is at rest the greater the likelihood of satisfactory healing.

AFTERMATH — It is essential for the patient to be seen at regular intervals; every 3 months for 1 year, every 6 months for 2 years, then once a year for the rest of his life. • He is told to report immediately if he has pain, a lump, or paraesthesia or weakness of the legs.

COMPLICATIONS

GENERAL —
General complications have been described on page 26. Of special importance in the spine are (*a*) the complications due to prolonged recumbency (especially renal calculi) and (*b*) the coexistence in many cases of tuberculosis elsewhere, notably in the lung or urogenital tract. It should not be forgotten that a second focus of tuberculosis may exist in another part of the spine.

LOCAL —
Flare — Reactivation of the disease is common and presents with renewed backache, often further collapse and sometimes paraplegia.
Abscess — An abscess is an almost invariable finding, but is usually only manifest as a paravertebral shadow on x-ray. It may extend to press on the cord. Very rarely a superficial cold abscess may present on the posterior or lateral aspect of the chest wall; nearly always, however, such abscesses arise from tuberculous glands at the rib angles or from an empyema.
Pott's paraplegia — This is simply the name for paraplegia associated with spinal tuberculosis. It is a common and grave complication, meriting separate description.

POTT'S PARAPLEGIA

Much of the following account is based on that of Griffiths, Seddon and Roaf.

PATHOLOGY

SOFT INFLAMMATORY MATERIAL — Soft inflammatory material may compress the cord; the material is usually an abscess but sometimes it is granulation tissue or a caseous mass. Such pressure accounts for two thirds of paraplegias of early onset (while the disease is active). Inflammatory material can shrink with healing, so that spontaneous recovery is possible; if operation proves necessary simple evacuation of an abscess may be sufficient.

SOLID MATERIAL — Solid matter may compress the cord, or the cord may be stretched over it. Usually the cause is a bony ridge at the kyphos, sometimes sequestrated bone or disc or both, and occasionally there is a true pathological dislocation. These causes account for two thirds of late-onset paraplegias (after activity has completely subsided). Solid material cannot shrink, and recovery without full-scale decompression is impossible.

FIBROSIS — Fibrous tissue may strangle the cord transversely and after many years the cord shrinks longitudinally.

The distinction between early and late cases is not so sharp as was formerly supposed.

IN ADOLESCENTS — A high scoliosis or Scheuermann's disease may give an adolescent patient a hunched back, but the history is different and in neither condition is there true bone destruction or an abscess.

IN ADULTS — The persistence of deformities arising in childhood or adolescence may confuse the diagnosis in adults.

IN ELDERLY PATIENTS — Kyphos with backache in an elderly patient may be due to a pathological fracture, whether through malignant disease or senile osteoporosis. In neither of these conditions is there an abscess. In osteoporosis (*see* page 55) the discs are ballooned and, in a fracture through malignant disease, only one body is affected.

PYOGENIC OSTEOMYELITIS — Pyogenic osteomyelitis of the spine can occur. The patient becomes rapidly ill with high fever and severe back and root pain. The x-ray appearance is at first normal and later shows sclerosis.

TREATMENT

ACTIVE STAGE — Recumbency, sanatorium régime and drug therapy are imperative and may need to be prolonged. The essential features of local treatment resemble those in the treatment of joint tuberculosis, namely rest, stretching and drainage.

Rest — An adult patient is treated in a plaster bed which is mounted on a wooden frame to allow room for bedpans. An anterior plaster turning-case is used when the patient's back needs cleaning.

A child is treated on a metal and leather frame to which the trunk is attached by a canvas bodice; skin traction is applied to the legs. By this means, the spine can be [illegible] deformity is usually not severe. [illegible] ıe affected area) and make the plaster bed fit the kyphos.

In children, kyphos is liable to become severe and the deformity is corrected in the following way. The back is gradually hyperextended by angulating the frame (to which the child is tied) at the site of the kyphos. When satisfactory straightening has been achieved, the position is maintained until healing is well advanced and is then made *permanent by a bone graft. Although hyperextension delays healing it minimizes* deformity, and in children the extra time is well spent. Some surgeons prefer to save *time by allowing a little collapse and encouraging compensatory curves.*

Drainage — A modern method which probably accelerates healing is to evacuate all infected material and insert bone chips; in skilled hands and under antibiotic cover, this method has a promising future. A paravertebral abscess is sometimes drained in the hope of preventing paraplegia.

HEALING STAGE — The patient is taken off his frame or plaster bed and a plaster jacket is applied. In this he moves about in bed and his back and leg muscles are exercised. He is allowed up in progressive stages, first sitting, then standing, then walking for increasing periods. The plaster is then replaced by a brace which is later left off at night. In adults the brace may sometimes be eventually discarded, but a child must continue to wear it until he is fully grown.

Bone grafting — This is sometimes performed when healing is well advanced. It is not

lesion is not too high, the patient can get up with calipers and crutches or a wheel-chair. The principles of treatment are similar to those in traumatic paraplegia (*see* page 318).

TUBERCULOSIS OF THE LUMBAR SPINE

PATHOLOGY

Bone collapse occurs as in thoracic disease, but forward angulation is less marked, partly because slight angulation merely straightens out the normal lumbar lordosis, and partly because the plane of the articular facets is such as to permit a more directly vertical collapse. Occasionally lateral angulation occurs.

SYMPTOMS

The onset is even more insidious than that of thoracic tuberculosis, and pain is so slight that the disease is rarely diagnosed early. Hence the statement that "lumbar tuberculosis is often an ambulant disease". Sometimes the presenting feature is a large abscess.

SIGNS IN ACTIVE STAGE

LOOK — A kyphos is rarely visible, but an abscess in the loin or groin is not uncommonly seen and the back muscles may be in spasm.

FEEL — Although forward angulation is often too slight to be seen, it can be felt as a small but definite knuckle. The groin should always be palpated for a cold abscess even if no abscess has been seen.

MOVE — Movement is limited in all directions. Even if spasm was not previously obvious, attempted movement provokes it. The back should be carefully watched while movements are attempted. Formerly, the coin test was used: a child with lumbar spasm prefers to pick up a coin by bending at the hips and knees rather than at the spine.

With disease at the lumbosacral junction limitation of movement is scarcely detectable.

X-RAY — Two adjacent vertebral bodies show destruction and the intervening disc space is narrowed. Forward angulation and wedging are often slight.

HEALING STAGE

With healing, pain disappears and the slight deformity may pass unnoticed. X-rays show recalcification often with bony fusion between affected vertebrae.

DIFFERENTIAL DIAGNOSIS

Because deformity is slight, diagnosis is from other causes of backache or stiffness.

IN ADOLESCENTS — Lumbar osteochondritis presents between the ages of 10 and 15 years with intermittent ache and stiffness, chiefly after activity. On x-ray the condition resembles tuberculosis in that the anterior corner of a vertebral body (L.1 or L.2) looks eroded and the disc space narrowed. But, unlike tuberculosis, in osteochondritis the "erosion" has a sclerosed margin and the vertebra below the narrow disc looks expanded. The condition is probably a minor growth disorder and recovers spontaneously.

A paraplegia which is clinically late in appearing may still be due to pressure of soft inflammatory material if it is associated with a flare or with a second spinal focus; some spontaneous recovery can then occur.

CLINICAL FEATURES

Paraplegia may be the presenting feature in spinal tuberculosis or may develop at any time afterwards, even long after healing has occurred.

There is always clinical or radiological evidence of the underlying disease. The symptoms and signs peculiar to the paraplegia *itself* are as follows.

MOTOR — Clumsiness, incoordination and weakness are the early symptoms. Later there is loss of voluntary power and increased muscle tone with brisk tendon reflexes, clonus and extensor plantar responses. Still later, painful flexor spasms and contractures may occur. (The abdominal reflexes may be absent.)

SENSORY — Paraesthesia is an early symptom. Later there is numbness and sometimes a band of hyperaesthesia at the upper level of the lesion.

VISCERAL — Disturbances of bladder control (urgency, frequency and often incontinence) occur in two thirds of cases. Rectal disturbances are less frequent.

CONSERVATIVE TREATMENT

The general and local treatment of the underlying tuberculous process (already described) must be begun immediately and must be thorough. Often the paraplegia (especially if it complicates active disease) slowly subsides.

OPERATIVE TREATMENT (DECOMPRESSION)

Decompression is indicated if (*a*) paraplegia comes on suddenly, or (*b*) the paraplegia does not recover despite adequate immobilization and antibiotics. (The modern view is that voluntary muscle power is the decisive factor; as long as some control is retained, or rapidly returns, there is no need to operate. If it has been completely lost, operation should not be delayed for more than 4 weeks.) It is also necessary if (*c*) paraplegia recurs after having recovered, which is not uncommon.

METHODS OF DECOMPRESSION —

Antero-lateral — Antero-lateral decompression has the widest application and is the method of choice, but the operation is difficult. Three ribs are resected and the theca exposed by nibbling a way along the intercostal nerves. Sequestrated and necrotic material is removed, and any bone ridge bevelled off. At a later operation the spine is grafted.

Costotransversectomy — Costotransversectomy is indicated only if bony disease has been present for less than 2 years and x-rays show a well-marked paravertebral abscess.

Laminectomy — Laminectomy was formerly used, but has been abandoned except possibly for cervical tuberculosis.

PALLIATIVE TREATMENT

If the paraplegia does not recover, the patient's plight may still be ameliorated. It is important to prevent pressure sores and urinary infection. Muscle contracture should if possible be avoided, but tenotomies may be necessary. Providing the

REGIONAL SUMMARY OF TUBERCULOSIS

The following Table, based on that of Perkins, draws attention to the leading features in tuberculosis at various levels of the spine.

TUBERCULOSIS OF THE SPINE

Level	Deformity	Abscess	Spasm	X-ray	Comments
C.1–C.2	None	Retropharyngeal	Present	Difficult to interpret	Very rare
C.3–Th.2	Sometimes torticollis or loss of lordosis	Behind sternomastoid muscle	Present	Wedging obvious	Rare: may give rise to tetraplegia
Th.3–Th.11	Kyphos and kyphosis	Often only seen by x-ray	Absent	Collapse, wedging, abscess	Common: may give rise to paraplegia
Th.12–L.4	Often none	Common, especially psoas abscess	Present	Narrow disc, sometimes wedging	Common: diagnosed late
L.5–S.1	None	Usually in buttock	Absent	Often only narrow disc	Often diagnosed as disc prolapse

DEFORMITIES

SCOLIOSIS

Seen from the back the normal spine is straight; deviation to one side constitutes scoliosis.

CLASSIFICATION

There are many classifications; a simple and useful one is into three groups: (*a*) mobile scoliosis; (*b*) fixed scoliosis; (*c*) "neuropathic" scoliosis (also fixed).

MOBILE SCOLIOSIS — Mobile scoliosis may be (*a*) postural; (*b*) compensatory; or (*c*) hysterical. A mobile scoliosis can be corrected by the patient or the doctor. It is not accompanied by vertebral rotation and never develops into a fixed curve.

Postural — This condition is common especially in adolescent girls. The curve is usually slight and single, without accompanying rotation. The curve disappears when the child hangs from a bar or bends forwards.

Compensatory — Any asymmetry, such as eyes which are not level, torticollis, thoracoplasty, a short leg or a deformed hip may cause scoliosis. The cause is usually obvious; a curve resulting from leg asymmetry usually disappears when the patient sits.

Hysterical — The curve is often gross and unbalanced; other stigmata of hysteria are present.

FIXED SCOLIOSIS — Only three varieties of fixed scoliosis are common: (*a*) congenital; (*b*) paralytic; and (*c*) idiopathic.

Nevertheless it should be treated as an "observation spine" until tuberculosis is definitely excluded.

IN YOUNG ADULTS — In young adults ankylosing spondylitis presents with low backache and stiffness in a slightly unfit patient with a high sedimentation rate. X-rays show changes in the sacroiliac joints and, later, calcification of ligaments. There is neither bone destruction nor narrowing of the disc space.

Sacroiliac tuberculosis presents with slight backache in young adults. An abscess in the buttock is an almost invariable finding and is often the presenting feature. X-rays show the sacroiliac joint to be widened and "fluffy" in appearance, with areas of destruction usually in both ilium and sacrum. Associated lung tuberculosis and urogenital disease are common. Treatment is by antibiotics and rest in a plaster bed. Later, it may be worthwhile to try to excise the diseased area and arthrodese the joint.

IN ADULTS — In adults, disc prolapse may sometimes present with continuous backache instead of the more usual attacks of lumbago and sciatica. However, the patient is fit and back movements are usually full in at least one direction. X-rays show a narrowed disc space but no bone destruction. (At the lumbosacral junction bone destruction can be excluded only in lateral x-rays of the highest quality.)

Lumbar spondylosis presents with back pain and stiffness. The patient, however, is fit and x-rays show no bone destruction, only lipping and osteophytes.

Malignant deposits present with back pain in an unfit patient, but destruction is usually confined to a single vertebral body, and the disc space is not narrowed.

TREATMENT

Treatment is the same as for thoracic disease except that hyperextension is unnecessary, even in children, because the tendency to forward angulation is slight.

A spine graft is valuable when healing is well advanced; but extensive lumbar grafts often fail to fuse, and shorter ones may fail to include a vertebra in which disease has not been apparent on x-ray. Tomograms often reveal otherwise unnoticed disease and so enable the correct length of graft to be assessed.

COMPLICATIONS

A focus of disease elsewhere in the body is common and so is a flare even many years after apparent healing, especially with disease of the thoracolumbar junction.

Paraplegia may occur in thoracolumbar or high lumbar disease; below this level only the cauda equina can be pressed upon.

An abscess is the commonest complication. The caseous pus either extends into the loin, or tracks along the psoas sheath to give an abscess above Poupart's ligament, or below it, or both above and below with cross fluctuation. Sometimes the abscess extends down the thigh. It is "cold", usually painless, and often large and fluctuant. As the abscess approaches the skin, there may be a little pain and pyrexia, the precursors of a sinus. The abscess should be aspirated under rigidly aseptic conditions and using a short-bevel needle which enters the skin obliquely. If the abscess recurs it is incised, evacuated and the skin sutured. A sinus is protected with sterile dressings and streptomycin may be instilled into it.

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Hysterical — The curve is often gross and unbalanced; other stigmata of hysteria are present.

FIXED SCOLIOSIS — Only three varieties of fixed scoliosis are common: (*a*) congenital; (*b*) paralytic; and (*c*) idiopathic.

A fixed or structural scoliosis cannot be completely corrected by the patient or the surgeon and is always accompanied by rotation of vertebrae.

Congenital — Congenital scoliosis is due to failure of development of one half of a vertebral body. Rib abnormalities, spina bifida and skin naevi are often associated. Multiple congenital deformities sometimes occur and are often less deforming than a single hemivertebra because they may balance each other.

Paralytic — This condition occurs mainly after poliomyelitis with unbalanced trunk paralysis (*see* page 82), though rare muscle dystrophies are occasionally responsible. In children it tends to be progressive and severe because gravity helps the stronger side but, unlike other varieties of scoliosis, it can increase even after spinal growth is complete. Usually the curve is very long and "telescopic", but after a time it is not correctable.

Idiopathic — This is the commonest variety, and the cause is unknown. It is never a sequel to postural scoliosis, nor can unrecognized poliomyelitis of the small back muscles explain the sex and age distribution. It is conceivable that defective growth of the neural arches (Somerville) or displacement of the epiphyseal plates (Farkas) might be factors.

"NEUROPATHIC" SCOLIOSIS — Three rare varieties of fixed scoliosis occur in association with disorders of the nervous system: (*a*) syringomyelia; (*b*) Friedreich's ataxy; and (*c*) multiple neurofibromatosis (von Recklinghausen's disease).

Syringomyelia — In syringomyelia high thoracic scoliosis is common. Charcot's neuropathy may affect joints (mainly in the upper limbs). There is loss of pain and temperature sense, spastic weakness, trophic changes and often claw hands.

Friedreich's ataxy — Friedreich's ataxy is commonly associated with scoliosis, and pes cavus is invariable. The condition is familial and presents between the ages of 5 and 15 years with increasing clumsiness, ataxy, tremor and slurred speech.

Multiple neurofibromatosis (von Recklinghausen's disease) — In addition to the neurofibromata, most patients have "café-au-lait spots", some have hypertrophy of one limb and some have scoliosis.

"*Sciatic scoliosis*" — This is not a true scoliosis (*see* Prolapsed Disc, page 178).

PATHOLOGY

In mobile scoliosis, there are no pathological abnormalities of the spine. In fixed scoliosis the deformity is in three planes: (*a*) lateral deviation from the midline; (*b*) rotation, the spinous processes twisting towards the midline; and (*c*) kyphosis, which accompanies the scoliosis.

Fixed scoliosis is progressive. It may increase (by no means always) until spinal growth is complete. (Risser's sign: when the iliac apophyses have appeared throughout their length, spinal growth is complete and the curve is "mature".) Deformity may increase after spinal maturity in only two varieties of fixed scoliosis, namely, paralytic scoliosis and scoliosis associated with von Recklinghausen's disease.

The curve is usually a triple one: the middle curve is primary and fixed from the start; the compensatory curves above and below may later become fixed. Occasionally double or quadruple curves occur.

Secondary changes, such as wedging of the vertebrae and deformities of the chest wall, occur later.

SYMPTOMS

The symptoms peculiar to the scoliosis are as follows.

DEFORMITY — This is the only symptom of a thoracic curve. The higher the curve the more obvious the deformity.

PAIN — A lumbar curve may pass unnoticed until the age of 30 or more years, when pain tends to occur. Occasionally root pain develops in a long-standing thoracic curve.

GENERAL SIGNS

Idiopathic scoliosis mainly affects young adolescents aged 10–12 years and girls much more often than boys (in the proportion 4 : 1). Occasionally the curve is first seen in infancy. In idiopathic scoliosis deformity is the only abnormality found.

Every patient with a fixed scoliosis must be examined for neurological disorders, skin pigmentation and inequality of leg length.

LOCAL SIGNS

LOOK — In fixed scoliosis, part of the spine is deviated from the midline and rotated. Rotation causes the rib angles to protrude on the convex side. The chest is distorted and one hip sticks out. There are compensatory curves above and below the primary curve, so that the spine remains balanced with the head directly over the pelvis.

FEEL — Rib angles and spinous processes can be felt.

MOVE — When the patient bends, a postural scoliosis disappears. Conversely, with a fixed curve, deformity becomes more obvious on bending because the angles of the ribs protrude (razor back).

X-RAY — X-rays are necessary for two reasons: (*a*) to exclude congenital hemivertebra or vertebral disease; and (*b*) to measure the curve accurately for assessment of progress.

Curve patterns — In idiopathic scoliosis, there are several curve patterns. A primary thoracic curve is usually convex to the right and is observed early because deformity is obvious. A primary lumbar curve is usually convex to the left, and presents late (with pain) because there are no ribs to accentuate the deformity. Intermediate types also occur. Sometimes there is a primary lumbar and a primary thoracic curve which balance each other and cause little deformity.

CONSERVATIVE TREATMENT

A mobile curve is always treated conservatively. If it is postural in origin, the child is trained to stand correctly; if there is inequality of leg length a raised shoe may be helpful. Even a fixed curve is nearly always treated conservatively, and the essentials of treatment are as follows.

OBSERVATION — At 3-monthly intervals, the patient is examined, photographed and x-rayed so that the curve may be measured.

EXERCISES — These neither reduce the curve nor halt its progress, but they help to keep the back supple and, aided by artful dressmaking, the curve may be hidden.

SUPPORTS — Most types of brace are useless. They attract attention to the deformity, and they need constant adjustment as the increasing curve makes them uncomfortable.

The following two varieties are, however, useful in young children to hold a curve stationary until the minimum age for fusion (10–12 years).

Abbott jacket — The Abbott jacket is a plaster jacket in which a window over the lower ribs on one side is so designed that breathing tends to straighten the curve.

Milwaukee brace — In the Milwaukee brace adjustable steel supports transfer stress from the chin and occiput to the iliac crest. By extending the steels the curve can be straightened a little, but the brace is very irksome.

RECUMBENCY — Recumbency halts the progress of a scoliosis, but it is impracticable to keep a patient recumbent until spinal growth is complete.

OPERATIVE TREATMENT

Operation is indicated only if deformity is severe or likely to become so.

Risser's technique is to apply a plaster which includes the head and thigh on the concave side of the primary curve. The plaster is divided horizontally at the level of the apex of the curve. Hinges and a turnbuckle are incorporated so that the curve can gradually be racked straighter over a period of a few weeks. The plaster is then completed and, through a window cut in it, the entire primary curve fused. In paralytic scoliosis the area to be fused is often extensive.

To some extent a razor-back deformity can be minimized by excising the prominent rib hump.

KYPHOSIS

CLASSIFICATION

MOBILE KYPHOSIS — Mobile kyphosis may be (*a*) postural; (*b*) associated with muscle weakness, as in poliomyelitis; or (*c*) compensatory to lumbar lordosis with hip deformity. Mobile deformities are not in themselves important, though they may in later life cause backache. They are correctable either by the patient's own muscular efforts or (with the patient lying on a couch) by the surgeon.

Postural — Postural deformities are common, and are associated with other postural defects, such as flat feet or prominent abdomen. They occur most often in adolescents, in women after childbirth and in middle-aged people who have become fat. The treatment is corrective exercises and posture training.

Muscle weakness — Weakness of the trunk muscles, as in muscle dystrophies and poliomyelitis, is often associated with lumbar lordosis and thoracic kyphosis.

Compensatory — Gross hip deformity, such as congenital dislocation or fixed flexion, is accompanied by excessive lumbar lordosis which is balanced by thoracic kyphosis.

FIXED KYPHOSIS — The following varieties of fixed kyphosis occur: (*a*) Scheuermann's disease (*see* page 175); (*b*) ankylosing spondylitis (*see* page 176); (*c*) senile kyphosis (*see* page 177). Some bone dystrophies are associated with kyphosis, but this is not the presenting feature (*see* Chapter 6)

A fixed kyphosis cannot be corrected by the patient or the surgeon; it is balanced by a lumbar lordosis unless the lumbar spine also is stiff, as in ankylosing spondylitis or senile kyphosis.

ANGULAR KYPHOSIS (KYPHOS) — Angular kyphosis may occur in the following conditions:

(*a*) tuberculosis; (*b*) following a fracture (which may be pathological); and (*c*) Calvé's disease. A kyphos is always fixed. The distinction between a sharp angular kyphos and a smooth kyphosis is of the utmost help in diagnosis.

AGE OF ONSET — The age of onset is a further valuable pointer to diagnosis. In children, kyphosis other than that due to tuberculosis or postural defects is rare; in adolescents, postural kyphosis and Scheuermann's disease are common; in young adults, ankylosing spondylitis is an important cause; in the elderly, senile kyphosis, pathological fractures and Paget's disease must be considered; at all ages, tuberculosis must be excluded.

RIGID KYPHOSIS OF ADOLESCENCE (SCHEUERMANN'S DISEASE)

CAUSE

The cause of this condition is unknown.

Scheuermann used the term osteochondritis because the epiphyseal plates are irregularly ossified.

Schmorl drew attention to the function of the cartilage plates in transmitting pressure evenly and suggested that a defect in them threw undue strain on the anterior portion of the vertebral bodies.

Lambrinudi suggested that when a patient flexes, the epiphyseal plates may be damaged if hip flexion is limited by tight hamstrings. This seems the most convincing explanation.

SYMPTOMS

The parents complain that the child is becoming increasingly round-shouldered. There may also be low thoracic pain. In middle life lumbar pain often develops in the compensatory lordosis.

SIGNS

The patient is an otherwise fit adolescent aged 13–16 years.

LOOK — A smooth thoracic kyphosis is seen and may be severe. Below it is a compensatory lumbar lordosis.

FEEL — No abnormality can be felt.

MOVE — The deformity cannot be corrected by the patient or the surgeon. Lumbar spine movements are normal. Straight-leg raising is often limited to 60 degrees by tight hamstrings.

X-RAY — The bodies of several adjacent vertebrae, usually the Th. 6–10, are wedged; that is, narrower in front. They may contain small translucent areas (Schmorl's nodes). The epiphyseal plates appear fragmented, especially anteriorly.

DIFFERENTIAL DIAGNOSIS

Postural kyphosis is common in adolescence. It is painless, and the deformity is correctable by the patient's own efforts if he is properly instructed. The curve is a long one and other postural defects are common. The X-ray appearance is normal.

Tuberculosis produces an angular kyphos. X-rays show destruction of at least

two adjacent vertebrae with narrowing of the intervening disc and often a paravertebral abscess.

TREATMENT

AMBULANT TREATMENT — This is indicated if there is little pain and the deformity is not severe. The patient is taught to stand as well as possible. Any slight ache disappears within 12 months.

RECUMBENT TREATMENT — Recumbency on a flat bed or a posterior plaster shell is rarely indicated and only if pain is severe, deformity considerable and spinal growth is not yet completed. When pain disappears the patient gets up, and wears a brace until spinal growth is complete.

ANKYLOSING SPONDYLITIS

CAUSE

The cause of ankylosing spondylitis is unknown. In the United States of America, the disease is called rheumatoid spondylitis, but it is totally different from rheumatoid arthritis. It is not gonococcal, though there is a curious relationship between non-specific urethritis, joint stiffness and conjunctivitis, as in Reiter's disease.

PATHOLOGY

The pathology is unknown, but van Swaay has suggested that articular cartilage in affected joints proliferates and a cartilaginous ankylosis develops which may later become bony. The underlying bones are not abnormal, nor are the intervertebral discs. The capsule of affected joints becomes secondarily calcified; calcification also occurs in the ligamentous shell surrounding the intervertebral discs.

SYMPTOMS

Stiffness and backache, especially a constant dull ache in the buttocks or posterior thighs, are usually the first symptoms. They come on gradually; large limb joints may later become painful and stiff.

The patient usually feels unwell and may have lost weight.

GENERAL SIGNS

The disease affects men much more often than women (in the proportion of 9 : 1). It usually begins between the ages of 15 and 35 years, with 20–25 years as the peak period. It pursues a long course over several years, with phases of activity during which additional areas may become affected. The disease process may stop when only the low back has been involved, or not until the entire spine and several large limb joints have stiffened. The patient is nearly always thin and, while the disease is active, he looks ill, the sedimentation rate is raised, and there is often anaemia. Iritis occurs at some stage in 10–20 per cent of cases.

LOCAL SIGNS

LOOK — A severely affected patient stands in a characteristic way; the back forms one continuous curve from sacrum to head and the knees are bent to maintain balance. Even in milder cases the normal lumbar lordosis is usually absent.

FEEL — Sometimes there is tenderness over the manubriosternal joint, iliac crests and symphysis pubis.

MOVE — The lumbar spine is stiff but the unwary may be misled by mobile hips. Chest expansion is permanently and grossly reduced—a diagnostic feature. The limb joints, especially the hips and sometimes other large joints, may be stiff. Small joints are unaffected. Except during active phases of the disease, attempted movement is not painful.

X-RAY — The earliest changes are seen in the sacroiliac joints; the joint line becomes blurred and irregular with surrounding sclerosis. The vertebral bodies are normal in shape; their borders are well-defined or even sclerosed and the interior architecture lost. Calcification of the intervertebral ligaments completes the classical picture of a "bamboo" spine. Other joints may be obliterated.

TREATMENT

REST AND EXERCISE — While the patient is ill and the disease active, bed rest may temporarily be necessary, but it must be kept to a minimum and all efforts concentrated towards retaining mobility. Splintage is to be avoided as it increases the ultimate stiffness.

DRUGS — Aspirin is the safest and probably the best analgesic. Phenylbutazone is often effective, but its dangers must be borne in mind. Steroids are occasionally useful during exacerbations.

RADIOTHERAPY — Radiotherapy provides excellent palliation in what is probably a self-limiting disease. The pain is usually quickly relieved but restoration of mobility is seldom complete. It is impossible to irradiate sacroiliac joints in young women without risking genetic changes or sterility. Recent work suggests that radiation in this condition may lead to a slightly increased incidence of leukaemia.

"SALVAGE" OPERATIONS — If both hips are stiff, arthroplasty is worth trying after the disease has become completely quiescent. If kyphosis is so gross that the patient cannot see in front of him, osteotomy of the midlumbar spine can help.

KYPHOSIS IN THE ELDERLY

CAUSES

Kyphosis may begin in an elderly person in a variety of conditions.

TRUE SENILE KYPHOSIS — Degeneration of intervertebral discs probably produces the gradually increasing stoop characteristic of the ageing. The disc spaces become narrowed and the vertebrae slightly wedged. There is little pain unless osteoarthritis of the intervertebral joints is also present.

SENILE OSTEOPOROSIS — The patients, usually women, are thin and kyphotic ("dowager's hump"). There is widespread osteoporosis and the discs indent the soft vertebral bodies, which become biconcave. There may be pain, and pathological fractures are common. Treatment is described on page 55. (A similar condition may occur in younger people and is considered under Climacteric Osteoporosis on page 56.)

PAGET'S DISEASE — Considerable kyphosis occurs because of bone softening. There is

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usually evidence of Paget's disease (such as thick bent bones) elsewhere. The affected vertebrae are enlarged, and show coarse trabeculation.

PATHOLOGICAL FRACTURE IN MALIGNANT DISEASE — Usually the affected vertebra is the site of a secondary deposit and collapses with slight trauma. There is a kyphos and x-rays show that only one vertebral body is affected.

TREATMENT

The deformity itself requires treatment only if it is painful. A walking stick relieves the patient from the strain of forcing himself to stand upright. Heat and analgesics are soothing. A corset is often prescribed but is either too short to be effective or too high to be tolerated.

Senile and climacteric osteoporosis may benefit from dietary and endocrine treatment (*see* page 55). Pain due to a carcinomatous deposit is often relieved by radiotherapy.

DISORDERS OF INTERVERTEBRAL DISCS

The nucleus pulposus is normally under tension and surrounded by a fibrous annulus which, in turn, is held in place by ligaments. The disc space may be *too wide* because the bones are abnormally soft and the tense discs bulge into them, becoming biconvex. The main causes of soft bone are dysplasias, nutritional deficiencies, endocrine disorders and senile osteoporosis.

On the other hand, the space may be *too narrow* because disc material has degenerated or has been "displaced". Degeneration occurs in senile kyphosis. "Displacement" may be (*a*) prolapse of disc substance into the vertebral canal, which is the commonest cause of narrowing and is nearly always immediately above or below the sixth cervical or fifth lumbar vertebra; (*b*) extrusion around the periphery which occurs in spondylosis; or (*c*) protrusion into the vertebral bodies which occurs in Scheuermann's disease, causing Schmorl's nodes. The narrow space in tuberculosis is probably due to disc material squashing into the soft diseased body below.

LUMBAR DISC PROLAPSE

CAUSE

The factors concerned in disc prolapse are as follows.

INJURY — A lifting strain with the back bent may tear the posterior longitudinal ligament so that the tense disc bulges backwards. The annulus also may be torn and through the tear nuclear material is squeezed out, the torn annulus sometimes hinges into the vertebral canal. If a tear does not heal further prolapse is likely with trivial strains, such as coughing while the back is bent.

INCREASED TENSION — The nucleus may absorb fluid, swell and either bulge the annulus or burst through it. Fluid absorption occurs in some physical illnesses, and animal experiments suggest that it also occurs with emotional stress.

DEGENERATION — As it ages, the disc loses elasticity, partly because of physicochemical changes in the collagen fibres, and partly because its fluid content decreases (desiccation). The weakened disc is unable to resist body weight and is liable to bulge.

PATHOLOGY

Prolapsed disc material, whether a bulging annulus or a herniated nucleus, may press on dura mater (causing backache) or on nerve roots (causing backache or sciatica or both). The prolapse is nearly always immediately below or above the fifth lumbar vertebra. At first pressure may increase because of oedema or haemorrhage.

As oedema subsides the prolapsed material may shrink or slip back into place. If it remains prolapsed it may in time be absorbed or become adherent to root sheaths. Long-standing prolapse disturbs the mechanics of the intervertebral joints.

SYMPTOMS

FIRST ATTACK — The first attack is often sudden in onset and occurs while lifting or stooping, though sometimes pain is slight at first but increases over the next few hours. The patient may be fixed bent and has backache ("lumbago"); sometimes sciatica follows soon after, and both are made worse by straining. Usually these symptoms subside in a few days or weeks.

SUBSEQUENT ATTACKS — Subsequent attacks also may be sudden in onset, but often follow a trivial event such as coughing. The patient may complain of backache, of sciatica or of both; his pain is made worse by straining or stooping. Sciatic pain is usually felt in the buttock and radiates to the posterior thigh, outer calf and sometimes the toes. There may also be paraesthesia in this distribution and (rarely) weakness.

BETWEEN ATTACKS — Between attacks the patient may be completely normal, or may have a "lame back" which he is afraid to subject to stress.

GENERAL SIGNS

The patient is usually an adult male and in good general health. General examination shows no abnormality, that is, there is no anaemia, cachexia or abscess. The urine is clear and rectal examination reveals no abnormality.

It is essential never to omit general examination, because back pain and sciatica in an unfit patient may have a sinister significance.

SIGNS IN THE BACK

Between attacks the back may be normal. The signs during an attack are as follows.

LOOK — There may be deformity in two planes: slight forward tilt obliterating the lumbar lordosis; and lateral tilt, sometimes called "sciatic scoliosis".

FEEL — There is often tenderness in the midline of the low back and in the buttock.

MOVE — With acute lumbago all movements are limited for a day or two, and the muscles are in spasm. Later, movement is limited only in some directions, usually forward flexion and lateral flexion to either side, or sometimes extension. Full movement in any one direction is important for it strongly suggests a purely mechanical derangement.

SIGNS IN THE LEG(S)

During an attack there may be evidence of root pressure in one or both legs. (Rarely, a large central prolapse causes urinary disturbance.)

ROOT STRETCHING — Straight-leg raising is diminished and painful, and pain is increased by foot dorsiflexion or by head flexion. (Bent-leg raising, that is, flexing the hip joint, is unrestricted.)

SENSATION — This may be impaired, especially along the outer thigh, calf and foot.

MOTOR — There may be weakness, especially of the long extensor or flexor muscles of the hallux, and sometimes of the gluteal muscles.

REFLEXES — The ankle jerk may be diminished. (The knee jerk is affected only rarely and when the disc prolapse is higher than usual.)

X-RAY

X-rays of the lumbosacral spine are essential; their chief purpose is not to show a diminished space, but to exclude bone disease or deposit. The antero-posterior view may show a tilt. The lateral view often shows a diminished disc space, but a normal space does not exclude a small disc prolapse (even a small prolapse can produce severe symptoms).

Myelography can demonstrate the prolapse as a filling defect, but is rarely carried out unless a tumour is suspected.

LOCALIZATION OF PROLAPSE — The exact site of a prolapse is difficult to determine, but the following points may help.

Central prolapse (directly backwards) may produce backache and bilateral leg signs. Paracaudal prolapse (in the axilla of the root) causes pain which is made worse when the patient bends sideways away from the painful leg. Pararadicular prolapse (lateral to the root) causes pain which increases when he bends sideways towards the affected leg.

Postero-lateral prolapse below the fifth lumbar vertebra presses only on the first sacral root. It is likely to produce pain and paraesthesia along the outer thigh, leg and foot; weakness of the flexor hallucis longus muscle; and a diminished ankle jerk.

Postero-lateral prolapse of the disc above the fifth lumbar vertebra may press on the first sacral or fifth lumbar root or both It may produce pain and paraesthesia situated more antero-medially, weakness of the extensor hallucis longus muscle; a marked sideways tilt of the back; and cross-leg pain, that is, raising the good leg produces pain down the other.

X-ray — As a guide to the level of prolapse a diminished disc space on x-ray is unreliable. A previous prolapse may have narrowed the space and if the material has been absorbed it no longer causes symptoms

DIFFERENTIAL DIAGNOSIS

A patient with backache and sciatica usually has a prolapsed disc, but more serious conditions must be carefully excluded (*see* Causes of Backache and Sciatica, pages 184–185). It is especially important to exclude tuberculosis, tumours of the cord, meninges or nerve roots, and secondary deposits. The diagnosis is established as follows.

HISTORY — With a prolapsed disc the complaint is usually episodic; in most other disorders symptoms and signs are constant or progressive.

GENERAL EXAMINATION — With a prolapsed disc the patient is not unwell; in other disorders he may be ill or cachectic. An abscess or tumour should be carefully sought, and rectal examination should never be omitted.

EXAMINATION OF THE BACK — With a prolapsed disc movement in at least one direction is usually full. In tuberculosis or ankylosing spondylitis all movements may be restricted.

X-RAY EXAMINATION — With a prolapsed disc the vertebral bodies are normal in shape and the disc space is often reduced. In tuberculosis there is bony destruction of two adjacent vertebrae. With secondary carcinoma one vertebral body is affected. X-rays also reveal spondylolisthesis, lumbar spondylosis, an old fracture and disorders of the sacroiliac joint. Where doubt remains, myelography may be necessary to exclude a tumour of the cord, meninges or roots.

OTHER INVESTIGATIONS — With a prolapsed disc the blood count, sedimentation rate and urine are all normal. Lumbar puncture may be of value in excluding a tumour.

TREATMENT

Heat and analgesics soothe, and extension exercises strengthen the back; but there are only three ways of treating the prolapse itself.

REST —

Bed — With a severe attack the patient should go to bed with boards placed under the mattress to stop it sagging. He should, with a severe first attack, remain in bed for 6 weeks. 6

Corset — If the attack is less severe, or the patient cannot go to bed, a corset is worn. It may be made of plaster, polythene or canvas reinforced with steels.

Modified activity — If the attack is trivial he is advised to avoid stooping or lifting.

"REDUCTION" —

Traction — Skin traction applied to one leg is useful for a severe attack; the traction may open up the disc space and certainly enforces rest. If the patient cannot stay in hospital, a traction table is a fairly effective alternative; the pelvis and chest are racked apart for 20 minutes 3–4 times a week.

Manipulation — Manipulation is sometimes successful, especially with an attack of recent onset, but it should be avoided if there is sciatica.

Epidural injection — It is claimed that procaine (½ per cent solution) injected epidurally into the sacral canal may help to "reduce" a prolapse; at least 50 c.c., and often much more, is injected.

REMOVAL —

Operative removal effects lasting cure in only 80 per cent of cases; therefore it is indicated only if attacks are severe, disabling, recurrent, and persisting in spite of conservative treatment. In rare cases, a sudden paraplegia demands emergency operation

Methods — The following methods may be used.

Laminectomy — Through a midline incision the laminae are exposed, the muscles being stripped off them with wide chisels and held by self-retaining retractors. Half of the fifth

lamina on the side with most recent pain is nibbled off and the ligamentum flavum dissected away. The dura and root are gently retracted and the lumbosacral disc inspected. If prolapsed, bulging or unduly soft, the entire disc is plucked out piecemeal with pituitary forceps.

The disc above must be inspected even when a lesion has already been found, for both may be prolapsed. Unless a lesion consistent with the clinical findings has been demonstrated, cure is unlikely.

Other approaches — Some neurosurgeons remove a disc through a small interlaminar approach. If a tumour is suspected, a more extensive laminectomy is usual.

Disc removal and spine fusion — In theory this should prevent a weak back after laminectomy, but in practice the results are no better than after simple disc removal.

Rehabilitation — After recovery from a prolapsed disc or its removal, the patient is instructed how to lift properly by bending at the hips rather than the spine and taught exercises to restore suppleness and muscle power.

LUMBAR SPONDYLOSIS

PATHOLOGY

Several lumbar discs degenerate with age and lose their normal elasticity (*see* page 178). With the pressure of bodyweight disc material extrudes round the periphery; posteriorly it may adhere to nerve root sheaths, elsewhere it may calcify, producing lipping. Degenerative changes may also develop in the intervertebral joints, producing a true osteoarthritis.

SYMPTOMS

Backache is usually gradual in onset and eased by rest. Pain may also be felt in the groin or buttocks. Sometimes acute attacks of backache or sciatica supervene if more disc material prolapses.

SIGNS

The patient is over the age of 40 and fit in himself.

LOOK — The appearance is usually normal.

FEEL — Often tender areas are felt in the back or buttocks.

MOVE — All lumbar movements are limited and may be painful at their extremes. There may also be leg signs of nerve root pressure.

X-RAY — Several disc spaces are diminished, with lipping at the corners of the vertebral bodies. The intervertebral joints may be narrowed and irregular. (Identical changes may occur without any symptoms.)

TREATMENT

Heat and massage are soothing and manipulation occasionally helps, but a stiff lumbar corset, limiting extremes of movement, is the most effective treatment. Spinal fusion is rarely indicated.

SPONDYLOLYSIS AND SPONDYLOLISTHESIS

In spondylolysis, there is a gap in the neural arch. In spondylolisthesis, forward shift has occurred at the gap. In pseudospondylolisthesis there is forward shift without a gap.

CAUSE

There are two theories as to causation.

CONGENITAL — The neural arch might ossify abnormally in two separate centres leaving a gap in the bone (spondylolysis). In favour of this view, spondylolysis, a fairly common anomaly, often runs in families; however, no anatomical evidence for two ossific centres has been demonstrated, and the gap is rarer in children than in adults.

TRAUMA — A single injury or repeated strain might fracture the laminae and continual stress prevent bony union. Trauma can certainly account for the forward shift (spondylolisthesis) which sometimes takes place. Even if trauma is not the sole cause, it is a powerful aggravating factor. In favour of this view, the gap is at the pars interarticularis, an area susceptible to hyperextension sprains which are constantly sustained during toddling (Newman). However, forward shift occasionally occurs without any gap (pseudospondylolisthesis), the isthmus of bone between the superior and inferior facets being elongated.

PATHOLOGY

The gap, bridged by fibrous tissue, usually occurs in the fifth lumbar vertebra (occasionally the fourth). Behind it, the spinous process, laminae and inferior articular facets remain as an isolated segment.

With stress the vertebral body and superior facets in front of the gap may subluxate or dislocate forwards, carrying with it the superimposed vertebral column. The isolated segment maintains its normal relationship to the sacral facets.

There may be pressure on dura mater and the cauda equina, or on the emerging nerve roots; these roots may also be compressed in the narrowed intervertebral foramina. Disc prolapse is liable to occur.

SYMPTOMS

In children the condition is painless but the mother may notice the unduly protruding abdomen. In adolescents and adults backache is the usual presenting symptom; it is often intermittent, coming on after exercises or strain; occasionally it comes on suddenly after strain or violence. Sciatic pain may occur in one or both legs.

Spondylolysis, and even a well-marked spondylolisthesis, may be discovered incidentally during routine x-ray examination.

SIGNS

Y[illegible]
P[illegible] people.
The local signs of spondylolisthesis are as follows.

LOOK — The buttocks look curiously flat, the sacrum appears to extend to the waist,

and transverse loin creases are seen. The lumbar spine is on a plane in front of the sacrum and is too short. There may be signs of root pressure in one or both legs.

FEEL — A "step" is felt when the fingers are run down the spinous processes.

MOVE — Often movements are normal unless there has been a recent "attack".

X-RAY — The antero-posterior view shows that the upper border of the fifth lumbar vertebra is too low, on a level with the transverse processes. Lateral views demonstrate the gap in the laminae and any forward shift. Oblique views may show the laminae and the gap more clearly.

CONSERVATIVE TREATMENT

An acute attack is treated by a period of bed rest. Between attacks extension exercises should be practised and a lumbar corset worn. Manipulation is sometimes of value.

OPERATIVE TREATMENT

Operation is indicated only if there is considerable disability or severe root pressure. One of three operative procedures may be employed.

DECOMPRESSION — *Removing the isolated segment of bone behind the gap is a simple procedure and may relieve symptoms.*

POSTERIOR SPINAL FUSION — This is the standard procedure. If necessary a prolapsed disc can be removed at the same operation and the intervertebral foramina can be widened by nibbling away bone.

ANTERIOR FUSION — This is technically difficult to perform but fusion takes place more rapidly. The disc can, if necessary, be removed from the front but the roots cannot be seen nor the foramina widened.

TREATMENT AFTER RECENT INJURY

When a patient has pain after a recent back injury and is found to have spondylolisthesis, there are two possibilities: (*a*) that the injury has merely strained the fibrous tissue or caused disc prolapse (this is much the commonest, and conservative treatment as already described is indicated), or (*b*) that a recent laminar fracture-dislocation has occurred. This is suspected if the injury was severe and the margins of the gap are irregular. If so, closed reduction (by slinging the pelvis from a beam) may be tried, and if successful a double hip spica is worn for 6 months; more often operative reduction is necessary, and is held by grafts and screws.

CAUSES OF BACKACHE

There are many causes of backache and it is useful to group them.

INJURY

(*a*) *Twisting force*, causing muscle injury (sometimes with a fractured transverse process).

(*b*) *Lifting strain*, causing ligament injury. (i) posterior longitudinal ligament injury, permitting a prolapsed disc, (ii) interspinous ligament injury, causing a "sprung back".

(c) *Crushing force*, causing bony injury (compression fracture).

In all these the onset is sudden, after strain or violence; the patient is otherwise fit; and the x-ray appearance is normal or shows a fracture.

"DEGENERATION"

The back is mechanically unsound and joint degeneration has developed because of some underlying structural fault, which may be (a) *congenital*; for example, scoliosis, spina bifida; (b) *acquired*; for example, scoliosis, spondylolisthesis, kyphosis (thoracic kyphosis often gives lumbar pain because this area is constantly under strain to keep the patient upright); or (c) due to *lumbar spondylosis*.

In all these conditions the onset is gradual, though often there is a history of previous back trouble; the pain is worse after strain and better after rest; the patient has no general illness; and x-rays show osteoarthritis of the intervertebral joints and may reveal the deformity.

SPINAL DISEASE

(a) *Inflammation* — the most important chronic inflammatory conditions are tuberculosis and ankylosing spondylitis. Pyogenic osteomyelitis is rare but may present acutely.

(b) *Tumours* — The most common tumour is a secondary vertebral deposit. Other tumours may involve the cord, meninges or nerve roots. Vertebral haemangioma is often symptomless.

(c) *Paget's disease.*

In all these conditions the onset is not sudden or with violence; the patient may have other evidence of disease, and x-rays often reveal the cause.

DISEASE ELSEWHERE

Backache is common in non-spinal conditions such as (a) *any acute febrile illness*; for example, influenza; (b) *disorders of abdominal viscera*; for example, the stomach, duodenum, pancreas and urogenital tract; (c) *disorders, including carcinoma and presacral malignant deposits, of the pelvic viscera*; for example, the uterus, ovaries, bladder and rectum. (Hence the importance of rectal and vaginal examination.)

In all these conditions the onset is not sudden or with violence; there is other evidence of disease; and x-rays of the spine itself are normal.

"IDIOPATHIC"

There are so many patients in whom the cause of backache is never found that various unconvincing explanations have been put forward. The following are examples.

(a) *Fibrositis and myofasciitis.*

(b) *Sacroiliac strain.*

(c) *Osteitis condensans ilii.*

These are grist to the mill of the osteopath.

CAUSES OF SCIATICA

INFLAMMATION

Rarely, in sciatica, there is a true neuritis (often a polyneuritis) which may be (a) *toxic*; for example alcoholic or diabetic neuritis; or (b) "*infective*"; as in "focal sepsis", rheumatism, syphilis, and other conditions.

In all these conditions the onset is not sudden, the patient is unfit, and the nerve itself is tender.

COMPRESSION OF NERVE ROOTS

(*a*) *In the vertebral canal* compression is usually due to a prolapsed disc, occasionally to tuberculous material or to a tumour of the cauda equina or meninges.

(*b*) *In the intervertebral foramen* compression may arise from a tumour of the root, a lymphadenomatous deposit or because of narrowing of the foramen in spondylolisthesis.

(*c*) *In the pelvis or buttock* compression may arise from an abscess, if very large, or a tumour if impacted or adherent to the root.

In all these stretching the nerve is painful. A prolapsed disc is much the most common cause, and also the most innocuous.

"REFERRED"

Pain may be referred from an area of "*fibrositis*" in the back or buttock. Fibrositic pain is recurrent and often barometric.

In this condition there are tender areas on which pressure may also provoke sciatic pain; local anaesthesia abolishes both the local and the referred pain. The patient is otherwise fit, though other fibrositic or rheumatic affections may coexist. The x-ray appearance of the spine is normal.

Suggestions for further reading

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CHAPTER 18

THE HIP JOINT

EXAMINATION OF THE HIP

SYMPTOMS

THE four common symptoms of hip disorder are pain, which is in front rather than in the buttock and radiates to the knee; limp, which is often Trendelenburg in type; deformity, especially shortening; and stiffness.

The age of onset of symptoms often suggests the diagnosis: 0–5 years—congenital dislocation; 5–10 years—pseudocoxalgia; 10–15 years—slipped epiphysis; 20–40 years—osteoarthritis due to previous disorder; over 40 years—osteoarthritis (idiopathic), un-united fracture of the femoral neck, or Charcot's disease. Tuberculosis of the hip may occur at any age.

SIGNS WITH PATIENT LYING ON HIS BACK

LOOK —

Skin — Scars or sinuses may be seen.
Shape — Asymmetry, swelling or wasting is observed.
Position — There may be deformity or shortening.
Shortening — Shortening of the lower limb is analysed as follows.

Is it real or apparent? — Apparent shortening is due to fixed deformity. Real shortening means that the limb really is short. Both may coexist. With the lumbar spine and legs flat on the couch, the legs are placed parallel to each other and at right angles to the pelvis. If this positioning is possible there is no fixed deformity and any shortening is real; it may be roughly estimated by looking at the heels, and is measured from the umbilicus to each medial malleolus. To determine real shortening with accuracy, each limb is measured from the anterior superior iliac spine to the medial malleolus.
Is it above or below knee? — Both knees are flexed while the heels remain together on the couch. It is then obvious whether shortening is in the femur or tibia.
Is it above or below the great trochanter? — With a thumb pressed firmly against each anterior superior iliac spine, the surgeon gropes with his middle fingers for the top of each great trochanter. With the hands in this [illegible]

[illegible] and adducted the line normally crosses the top of the trochanter; or (*b*) to construct Bryant's triangle, in which a vertical line is drawn from the anterior superior iliac spine to the couch, and a perpendicular drawn from this line to the top of the trochanter; by comparing the length of the perpendicular at each hip, trochanteric elevation can be measured.

COMPRESSION OF NERVE ROOTS

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Is it above or below knee? — Both knees are flexed while the heels remain together on the couch. It is then obvious whether shortening is in the femur or tibia.

Is it above or below the great trochanter? — With a thumb pressed firmly against each anterior superior iliac spine, the surgeon gropes with his middle fingers for the top of each great trochanter. With the hands in this position, it is easy to estimate elevation of one trochanter. More formal methods of estimation are: (*a*) to draw Nélaton's line, which runs from the anterior superior iliac spine by the shortest route to the ischial tuberosity; with the hip flexed and adducted the line normally crosses the top of the trochanter; or (*b*) to construct Bryant's triangle, in which a vertical line is drawn from the anterior superior iliac spine to the couch, and a perpendicular drawn from this line to the top of the trochanter; by comparing the length of the perpendicular at each hip, trochanteric elevation can be measured.

FEEL —

Skin — The joint is too deep for excessive warmth to be detected.

Soft tissues — Synovial thickening and fluid are not detectable in the hip. Muscle bulk and tautness should be tested; but this is best done with the patient prone, as the glutei are the important muscles.

Bones — The method used for comparing the height of the trochanters is used in palpation. With the thumbs anchored against the anterior superior iliac spines, the middle fingers palpate each great trochanter. With the fingers pressing against the trochanters, the thumbs are moved medially in an attempt to feel the head of the femur; if the head is not in its socket, the thumb sinks in too far. Occasionally tenderness is elicited.

MOVE —

To test extension the sound hip is flexed until any lumbar lordosis is obliterated; if by this manœuvre the affected thigh is raised from the couch, then extension is shown to be limited (such limitation is by custom referred to as "fixed flexion").

Flexion of the hips is compared by flexing both simultaneously to their limit.

To test abduction both anterior superior iliac spines must first be level. The sound hip is then abducted until the pelvis starts to move; it is left in the abducted position while the affected hip in turn is abducted until the pelvis starts to move. In this way the difference in abduction of the two hips is easily seen.

Adduction is compared by moving each hip in turn and watching the pelvis for movement.

To test rotation both legs are lifted by grasping them at the ankles; they are then rotated first internally then externally. The patellae are observed as an index of the degree of rotation.

SIGNS WITH PATIENT LYING ON HIS FACE

LOOK — Scars, sinuses or wasting are noted.

FEEL — Muscle bulk and tautness are most easily assessed when the patient is prone.

MOVE — Extension of the two hips is most accurately compared with the patient lying on his face.

SIGNS WITH PATIENT STANDING

(1) The patient is asked to lift his bad leg by bending his hip and knee. (It is useful to ask the patient to lift his "bad leg" first, for this phrase is the least likely to be misunderstood.) The weight-bearing hip, which is the normal one, abducts and the pelvis consequently rises on the unsupported side.

(2) The patient is asked to lower the bad leg and lift the good one. He is now taking weight through the affected hip and, if there is a positive Trendelenburg sign, the pelvis drops on the unsupported side.

(3) He is observed while walking, then running, then hopping.

TRENDELENBURG'S SIGN — Normally each leg bears half the body weight. When one leg is lifted (as in normal walking) the other takes the entire weight. As a result the trunk has to incline towards the weight-bearing leg. This is achieved by the hip abductors; their insertion is fixed and the pull is exerted on their origin (the ilium). Consequently the pelvis tilts, rising on the side not taking weight. When this mechanism

fails Trendelenburg's sign is positive. The pelvis drops instead of rising on the unsupported side, and this occurs if (*a*) the abductors are weak, as in poliomyelitis or muscle dystrophies; (*b*) there is insufficient room for abduction, as in coxa vara where the trochanter meets the pelvic wall before the pelvis can tilt sufficiently; (*c*) the hip is dislocated so that the muscles have no stable fulcrum, as in congenital or pathological dislocations; or (*d*) the femoral neck is fractured so that the lever system is not intact. *Note* — Trendelenburg's sign may also be positive if it hurts the patient to put the abductors into action, as in inflammatory conditions.

X-RAY

Antero-posterior and lateral views are required and are examined in an orderly sequence.

(1) The general bone density is compared on the two sides.

(2) The [illegible] be dislocated, subluxed c[illegible] y be decreased or increase[illegible]

(3) The individual bones are examined, noting their shape, density and architecture; and finally, the component parts of each bone (periosteum, cortex and medulla) are inspected separately.

CONGENITAL DISLOCATION OF THE HIP

CAUSE

There are two main theories as to causation.

DYSPLASIA — A primary genetic defect of the acetabular roof is postulated, for even in the youngest patients the lateral portion of the acetabular roof always looks defective.

The dysplasia theory is consistent with the familial incidence of congenital dislocation of the hip (20 per cent of cases), and this may in turn be associated with the geographical distribution. (Congenital dislocation is often seen in North Italy and other mid-European countries where intermarriage is common.)

The roof defect may, however, be secondary to the dislocation because the roof usually re-forms after reduction.

PRESSURE — Abnormal intrauterine pressure or subsequent weight bearing may be responsible for dislocation.

In favour of this view, there is a high proportion of breech deliveries.

Against it, it is difficult to see why a hip dislocates if the acetabular roof is normal.

Possibly both these theories are partially correct and abnormal pressure produces dislocation only if the roof is defective.

PATHOLOGY

The pelvis is smaller on the affected side. The acetabular roof is defective on its lateral aspect so that the acetabulum is too shallow and its roof slopes too steeply. After weight bearing a false acetabulum develops above the original fossa. In bilateral dislocation the whole pelvis is tilted forwards for balance.

The bony nucleus of the femoral head appears later than on the normal side and remains smaller; the cartilaginous head, however, is large. The dislocation is always posterior and, as the head rides upwards, the slope of the pelvis pushes it laterally.

The femoral neck is usually too short and is often excessively anteverted. This anteversion is of considerable importance in treatment.

The capsule, unlike that in traumatic dislocation, remains intact. In time it becomes hourglass in shape, developing an isthmus where it is crossed by the psoas muscle. The glenoid labrum is often unduly large and folded into the acetabulum. The folded portion, sometimes called the limbus, constitutes an obstacle to reduction. The ligamentum teres is often thick.

Muscles arising from the pelvis become adaptively shortened. Hence it may be necessary to stretch the adductors before reduction is possible; and when a dislocation has been reduced the shortness of the hamstring muscles prevents the knee from being fully straightened (a useful test of reduction).

SYMPTOMS

There may be a family history of congenital dislocation and where such a history is present, the baby's hips should always be x-rayed in the first weeks of life.

Before walking starts, asymmetry is the main feature. One leg looks slightly shorter than the other, and the thigh and groin creases may be at different levels. Occasionally the mother may find it difficult to put on the baby's napkins (because of limited abduction) or she may notice that the hip clicks on movement.

Late walking as a symptom is probably overstressed, for congenital dislocation of the hip does not greatly delay walking. Nevertheless, if advice is sought because the child is a late walker, congenital dislocation must be considered.

After walking starts the asymmetry is obvious, but the main symptom is a painless limp (a dipping gait).

Nearly all the above symptoms refer to unilateral dislocation. Bilateral dislocation rarely presents early, because there is no asymmetry and the characteristic waddling gait is mistaken by the parents for normal toddling.

SIGNS

Unilateral dislocation is 5–7 times commoner in girls than in boys, and bilateral dislocation is 7 times commoner. The left hip is more often affected than the right and occasionally there are other congenital anomalies, such as a valgus foot.

LOOK — Asymmetry is the most obvious feature. The baby lies with one leg rotated outwards. The leg looks short, and the pelvis too "female" (that is, too wide) on the affected side.

The creases are asymmetrical but only differences between the levels of the groin creases are of much significance.

In bilateral dislocation there is no asymmetry but the pelvis is abnormally wide on both sides, and there is a perineal gap

FEEL — The head cannot be felt in its socket. A bony lump, possibly the head, can be felt in the buttock.

MOVE — Abduction is decreased; this is most obvious in flexion. The flexed hip of a young baby should abduct 90 degrees. In congenital dislocation it often stops halfway; but if pressure is then applied to it there is a click as the dislocation reduces and only then does the hip abduct fully. This sign (Ortolani) is present from birth. Telescopic movement is sometimes present, but is of little value in a baby.

If the child can stand, a positive Trendelenburg sign is observed; on walking, a Trendelenburg gait is seen. In bilateral cases the waddle is characteristic.

Measurements show that there is true shortening and the great trochanter is above Nélaton's line.

X-RAY — The head is too high and too far lateral. In early cases displacement is best detected by drawing Perkins' lines (a horizontal line through the triradiate cartilages and vertical lines from the outer edge of each acetabulum); the head should normally lie medial to the vertical and below the horizontal line.

The acetabular roof is defective so that the acetabular angle is increased. An arthrogram, obtained by injecting Perabrodil into the joint, may be useful; and occasionally special lateral views are taken to measure the anteversion of the neck.

DIFFERENTIAL DIAGNOSIS

Congenital dislocation must be differentiated from the following conditions.

OTHER CAUSES OF LATE WALKING — These include mental backwardness, and physical disorders such as spina bifida and cerebral palsy. Many late walkers are otherwise normal and do later walk normally. Nevertheless the hips should be x-rayed if walking has been unduly delayed.

OTHER CAUSES OF A PAINLESS LIMP SINCE INFANCY — The most important are as follows.
Poliomyelitis — In poliomyelitis trophic changes are present and there is other evidence of paralysis. Moreover the head is in its socket, although occasionally paralytic dislocation can occur.
Infantile coxa vara — In infantile coxa vara congenital dislocation is simulated except that the head can be felt in its socket and the x-ray appearance is different.
Pathological dislocation — In pathological dislocation there is a history of illness in infancy and a scar; x-rays show absence of the femoral head.

PRINCIPLES OF TREATMENT

BEFORE WEIGHT BEARING COMMENCES — It is generally supposed that weight bearing begins when the child walks; that is, at about 12–18 months; in fact, weight is being taken through the hip as soon as the child begins to crawl, at about 6 months. Before weight bearing occurs, treatment is simple and the prognosis excellent. That is why early diagnosis is so important and the appropriate examination should be carried out in all obstetric departments, as a routine.

AFTER COMMENCEMENT OF WEIGHT BEARING — Once weight bearing has begun, treatment is less easy and the prognosis only fair. Too often, in England, the condition is not seen before weight bearing has started.

ABOVE THE AGE LIMIT — There is an age limit above which reduction is extremely difficult

The bony nucleus of the femoral head appears later than on the normal side and remains smaller; the cartilaginous head, however, is large. The dislocation is always posterior and, as the head rides upwards, the slope of the pelvis pushes it laterally.

The femoral neck is usually too short and is often excessively anteverted. This anteversion is of considerable importance in treatment.

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The creases are asymmetrical but only differences between the levels of the groin creases are of much significance

In bilateral dislocation there is no asymmetry but the pelvis is abnormally wide on both sides, and there is a perineal gap.

FEEL — The head cannot be felt in its socket. A bony lump, possibly the head, can be felt in the buttock.

Shelf operation — A shelf operation may be performed either at the same time as open reduction or if it later becomes obvious that a good roof is not forming. A portion of ilium above the acetabulum is levered downwards and the gap packed with bone chips.

TREATMENT ABOVE THE AGE LIMIT

In unilateral dislocation the age limit is about 7 years (Putti). Above this age attempts at reduction often convert a painless limp into a painful one. Consequently the hip is best left alone until pain develops, which is often not until the age of 30 years or even later. Treatment may then be by osteotomy, arthrodesis or, rarely, arthroplasty.

In bilateral dislocation, the age limit falls to about 4 years. It is lower because (*a*) the waddle is less noticeable than the limp of a unilateral dislocation; (*b*) the patients lead completely normal lives, often until the forties or fifties; and (*c*) there is a danger that surgical intervention may convert a bilateral to a unilateral dislocation. When pain does develop it usually occurs in the back and is best treated (though not very effectively) by a corset and physiotherapy.

Various operative methods of hip reconstruction (such as Colonna's operation) are being attempted in patients who are older than the age limit but who have not yet developed pain. It is hoped that these methods may diminish the limp and prevent pain from developing.

CONGENITAL SUBLUXATION OF THE HIP

This is probably another manifestation of dysplasia. It is rarely diagnosed in childhood because of the absence of symptoms, though even at this age abduction in flexion is diminished and x-rays show a sloping instead of the normal horizontal acetabular roof.

If subluxation is seen early, possibly a shelf operation would help (Fairbank). As a rule, however, it is not seen until osteoarthritis develops, as it does in young people, often in the third decade of life. Congenital subluxation is probably the most potent source of osteoarthritis in the young, and the condition may rapidly become severe enough to require surgery.

PATHOLOGICAL DISLOCATION OF THE HIP

Probably this condition starts as an acute osteomyelitis of the femoral neck from which pus bursts into the hip joint with consequent acute arthritis. If the inflammatory condition is untreated the head and neck of the femur may be destroyed, and a pathological dislocation result. The pus may escape and, when the child recovers, the sinus heals. The hip signs then resemble those of a congenital dislocation, but the telltale scar remains and on x-ray the femoral head is seen to be completely absent.

and is probably unwise. According to Putti, the limiting age is 7 years for unilateral and 4 years for bilateral dislocations. Other surgeons give slightly different figures.

TREATMENT BEFORE WEIGHT BEARING

REDUCE — Abduction of the affected leg without anaesthetic effects reduction.

HOLD — Any method which keeps the hips abducted maintains the reduction; for example, Putti's divaricator, a stiff Frejka pillow, or a Denis Browne splint.

Abduction is maintained until a good acetabular roof is seen on x-ray, usually in 6–9 months.

TREATMENT AFTER WEIGHT BEARING BUT BELOW THE AGE LIMIT

REDUCE —

Closed manipulation — Closed manipulation under anaesthetic is the standard method. The hip is widely abducted (to stretch the adductors) then flexed and lifted upwards, pushing the head in from the buttock. Denis Browne affirms that this manœuvre is easier with the child prone. After manipulative reduction, in 25 per cent of the cases the head undergoes changes similar to those of pseudocoxalgia. This figure can be reduced to about 8 per cent by preliminary traction.

Preliminary traction — The patient is placed on an abduction frame and the legs gradually separated until abduction is full; a cross pull is then applied to the upper femur. Reduction often occurs within 4 weeks or is then easily achieved by the gentlest manipulation under anaesthetic.

Open reduction — Open reduction is indicated only if closed methods fail or if the hip dislocates again. At operation, the obstacle, usually an inverted limbus, is removed and the hip reduced. It is then easy to decide in which position reduction is most stable.

HOLD —

It is usual to maintain reduction by a plaster which holds both hips widely abducted and in the coronal plane ("frog" position). It is wiser, however, not to employ a uniform position for every case but to immobilize the hips in that position in which reduction is most stable.

Reduction must be held until the acetabular roof re-forms, usually in about a year. The plaster is changed every 3 months (with check x-rays), bringing the hips into a less abducted position towards the end of the year.

Denis Browne advises retaining plaster for only 6 weeks; a special splint is then applied which keeps the hips in the coronal plane but allows some movement. This valuable method is being widely adopted.

OPERATIVE METHODS —

In the age group under discussion the following operative methods may be used.

Open reduction — This has been considered above.

Rotation osteotomy — Rotation osteotomy is performed if, during open reduction, it is found that full internal rotation is required for stability. The femur is divided transversely below the great trochanter; above the osteotomy the hip is allowed to remain internally rotated, below the osteotomy the femur is externally rotated until the foot points forwards. Usually the osteotomy is held by a plate and screws, and is performed about 6 weeks after the open reduction.

SIGNS IN EARLY ACTIVE DISEASE

& Ext. rotation occurs

LOOK — The joint is held slightly flexed and abducted (to accommodate more fluid). The glutei and quadriceps muscles are wasted.

FEEL — Because it is deep, the joint is not accessible to palpation.

MOVE — Extremes of movement are limited and painful. If the hip is forcibly extended and rotated the iliopsoas muscle may be felt to go into spasm (Gauvain's sign).

X-RAY — There is general rarefaction but a normal joint space and line. The femoral epiphysis may be enlarged or a bone abscess may be visible.

SIGNS IN LATE ACTIVE DISEASE

LOOK — The joint is held flexed, adducted and internally rotated because of muscle spasm. The fixed adduction makes the leg appear short. Later, with increasing bone destruction, there is in addition true shortening.

FEEL — There may be deep tenderness in the groin and the trochanter may be raised.

MOVE — Movements are grossly restricted by spasm and attempted movement is painful.

X-RAY — In addition to general rarefaction there is destruction of the acetabular roof, or the femoral head, usually both; the joint may be subluxed or even dislocated.

SIGNS IN HEALING STAGE → Recalcification seen in x-ray

The patient's general condition is satisfactory and the joint no longer painful; these features suggest healing. Because the joint is deeply situated, the only confirmation that the healing stage has been reached is by x-rays, which show recalcification.

SIGNS IN AFTERMATH

Only occasionally does a tuberculous arthritis of the hip result in sound fibrous ankylosis; bony ankylosis occurs only if there has been secondary infection.

Usually there is a long unsound fibrosis which hardly merits the term ankylosis. The leg is short, thin and often scarred from sinuses or abscesses. There is fixed flexion, fixed adduction and often fixed internal rotation. Movement is grossly limited but often a range of flexion varying from 20 to 70 degrees remains.

DEFORMITY IN HIP TUBERCULOSIS

[illegible] because of fixed abduction; [illegible] on. [illegible] (*a*) destruction of bone (acetabulum or head); (*b*) damage to the upper femoral epiphysis and (if treated with prolonged immobilization) premature fusion of the lower femoral epiphysis; and (*c*) very occasionally a pathological dislocation may occur. It is because so many factors may contribute to the shortening in hip tuberculosis that it often becomes severe.

DIFFERENTIAL DIAGNOSIS

In practice, the only stage during which tuberculosis of the hip is difficult to diagnose is the early active stage, when the hip is irritable. A tuberculous irritable hip must be differentiated from the following conditions.

TREATMENT

Under anaesthesia, pus is aspirated and replaced by penicillin. Penicillin is also given intramuscularly, but may if necessary be replaced by other antibiotics when the organism has been cultured.

In addition, traction is essential to prevent the hip from dislocating.

SUMMARY OF HIP DISLOCATIONS

CONGENITAL

UNILATERAL — A painless limp is present since infancy.
BILATERAL — A painless waddle is present since infancy.
SUBLUXATION — Pain arises in young adult life.

ACQUIRED NON-TRAUMATIC

INFECTIVE —

Acute (pyogenic) — There is always a scar. No femoral head is seen on x-ray.
Chronic (tuberculous) — There is a long history of painful limp since childhood, and usually scars.

PARALYTIC —

In poliomyelitis or in spastic paralysis, unbalanced muscle action may produce a dislocation of the hip.

CHARCOT'S DISEASE —

There is a painless increased range of movement, telescopic movement and evidence of syphilis.

TRAUMATIC (*see* page 330)

There are three varieties. anterior, posterior, and central.

TUBERCULOSIS OF THE HIP

For a detailed description of the pathology, general features and general treatment of this condition, *see* Chapter 4.

PATHOLOGY

The disease process may start as a synovitis, or as an osteomyelitis in the bone of the acetabulum, femoral head or neck (The great trochanter may be affected, probably via a tuberculous bursitis; only rarely does this spread to the joint).

Once a true arthritis develops, destruction is rapid. Muscle spasm presses the femoral head against the acetabulum, which is soft and appears to enlarge upwards (wandering acetabulum), The femoral head may also be destroyed, permitting pathological dislocation

Healing usually leaves a long unsound fibrous joint with considerable limb shortening and deformity.

SYMPTOMS

At first there is intermittent limp and slight ache in the groin or knee. Later there is more pain, possibly night cries, and increasing stiffness and deformity, especially shortening.

HEALING STAGE — If the disease is arrested early, the aim is to regain movement while avoiding stress. First the child is taken off the frame and lies in bed on traction alone. Then traction is removed and he kicks free for a few weeks. If all is then well, he is allowed to get up but prevented from taking weight on the affected leg by fixing a patten to the good leg (thus making it longer) and using crutches. Gradually he is allowed to take a little weight on the affected leg, then more and for longer periods.

If the disease is arrested late, the aim is to hold the joint still in the optimum position for ankylosis—10 degrees abducted (more if short), 10 degrees flexed, and 10 degrees externally rotated A long hip spica of plaster is applied and weight bearing gradually increased. Later the plaster may be replaced by a polythene spica which is taken off for bed or bath.

AFTERMATH — For conservative treatment, a raised shoe, a walking stick and a removable polythene spica are all sometimes useful and may be the only treatment required.

Three operative procedures are possible.

Osteotomy (subtrochanteric) — Subtrochanteric osteotomy is useful to correct deformity and, by abducting the shaft, also increases apparent length. Sometimes the hip becomes sound after osteotomy.

Arthrodesis — Arthrodesis, preferably extra-articular, is the method of choice for unsoundness and instability. A bone graft may be slid up from the great trochanter (Hibbs), turned down from the ilium (Wilson), or bridged from the ischium to the femur (Trumble).

Osteotomy combined with arthrodesis (Brittain) — This is probably the best method of all. Subtrochanteric osteotomy is performed, and through the gap an ischio-femoral graft is inserted. The shaft is then abducted and plaster applied, and retained for about 6 months.

PSEUDOCOXALGIA

This example of the "crushing" type of osteochondritis (*see* page 41) is also known as Perthes' disease or Legg-Calvé's disease.

CAUSE

The femoral head loses its blood supply and dies (avascular necrosis). The cause is not known, but there are several theories.

TRAUMA — Gradual strain or an injury is the likeliest explanation, because half the cases have a history of injury, the condition is much commoner in boys, and similar x-ray changes follow forcible reduction of a dislocated hip. In half the cases, however, there is no history of injury. M[illegible] with an age distribution s[illegible] pseudocoxalgia the main source of blood supply to the femoral head is changing.)

DYSPLASIA — A minor subluxation or a sloping acetabular roof might impose strain on the capsule and thereby damage blood vessels. In pseudocoxalgia, as in these two conditions, the head is situated too far laterally in the acetabulum. This "standing away" is seen very early in the disease, but even so is probably secondary to the changes in the femoral head.

INFECTION — Although occasionally the patient is pyrexial for a time and staphylococci

TRANSIENT SYNOVITIS — Transient synovitis also presents as an irritable hip. The differentiation from early tuberculosis is difficult but important; early active tuberculosis must be diagnosed before the disease extends because prompt treatment may lead to resolution. The patient must be put to bed on traction and if the irritability does not quickly subside, radiological evidence of tuberculosis should not be awaited but iliac lymph-node biopsy performed.

PSEUDOCOXALGIA — The child is well. Abduction in flexion is the movement most restricted, and x-rays show the characteristically increased joint space and increased density of the femoral head with later fragmentation.

SLIPPED EPIPHYSIS — Slipped epiphysis may present in the early stage with pain, limp and an irritable hip. Age and build are characteristic and the x-ray appearance is diagnostic, providing a lateral view which shows the slip is taken.

CHRONIC MONARTICULAR SYNOVITIS — In an adult, chronic monarticular synovitis of the rheumatoid type may be indistinguishable without biopsy. Other joints later become affected.

OTHER CONDITIONS — At any age tuberculosis may be mimicked superficially by conditions outside the joint which are painful and may limit movement. These include the following.
Psoas spasm — This arises from infection in the retroperitoneal space, sacroiliac joint or spine.
Preparalytic poliomyelitis — Preparalytic poliomyelitis occasionally presents with a limp, pain and tender muscles. But there is usually meningeal irritation and paralysis soon follows.
Inflamed inguinal lymph nodes — Inflamed inguinal lymph nodes present no difficulty in diagnosis because the tenderness is superficial.

The above [illegible] of early tuberculosis. Once tuberculous arthr [illegible] is usually easy, because pyogenic arthritis is a [illegible]

The aftermath of tuberculosis is often a painful, stiff, deformed joint. The diagnosis is usually obvious (the differentiation from old suppurative arthritis, rheumatoid arthritis and osteoarthritis is considered on page 33).

TREATMENT

ACTIVE STAGE — In addition to recumbency, sanatorium régime and drug therapy, the essentials are rest, traction and drainage.
Rest — A double abduction frame is the most effective method. (This is merely a saddle with two Thomas' splints attached to it; the whole is mounted on a carriage.)
Traction — Traction is essential, to overcome spasm and to prevent collapse of soft bone. In children, traction is applied to both legs and fixed to the Thomas' splints, which are abducted gradually. In adults the same method can be used but is bulky. Often the splint is dispensed with and the patient treated on traction alone.
Drainage — A soft-tissue abscess may need to be aspirated or evacuated. A bone abscess in the femoral neck is probably best evacuated. Some surgeons go further and advise excision of all infected material.

are slightly diminished. Usually, however, there is no irritability; abduction, especially in flexion, is nearly always diminished and so is internal rotation. Other movements are usually full and painless.

X-RAY — From the outset, the joint space is increased and the head "stands away" too far laterally. Early in the disease the density of the head is slightly increased in a granular fashion. Later there is much more obvious increase of density and it is patchy. The head becomes flattened and fragmented. The neck becomes wide and often shows a band of rarefaction at the metaphysis. The acetabulum may show areas of altered density which are probably secondary.

DIFFERENTIAL DIAGNOSIS

Only in its earliest stages, when the hip is irritable, does pseudocoxalgia present difficulty in diagnosis, and then it must be distinguished from early tuberculosis in the following manner.

(*a*) In pseudocoxalgia the patient is fit. There is no evidence of tuberculosis elsewhere and the Mantoux reaction is usually negative.

(*b*) In tuberculosis x-rays show general rarefaction of bone and a normal or decreased joint space.

(*c*) In pseudocoxalgia, recovery from irritability is rapid if the hip is rested.

TREATMENT

The patient must be kept in bed with skin traction to the leg as long as the hip remains irritable. While waiting for irritability to subside the patient is investigated to exclude tuberculosis (*see* page 28).

Once irritability has subsided the aim of treatment is to prevent weight bearing and thereby to diminish the degree of deformation of the femoral head. Almost all authorities hold this view, but opinions differ as to how weight relief is best enforced. Two facts should be borne in mind: (*a*) the head remains "plastic" for two or three years; and (*b*) the prognosis appears to be the same whatever method of weight relieving is used.

Hence, keeping the child in bed on traction, or even on a double abduction frame (which in theory allows the femoral head to sink back into the acetabulum), seems too drastic. Simpler methods which permit ambulation (such as a weight-relieving caliper or slinging the affected leg from a collar and using crutches) appear adequate.

SEQUELS AND PROGNOSIS

The sequel to pesudocoxalgia is early osteoarthritis. Weight bearing while the femoral head is still soft, by increasing bone deformation, is likely to result in earlier or more severe osteoarthritis; but however gross the deformation, once irritability has subsided there are never any symptoms until adult life.

Age, however, is the most important factor in prognosis. The earlier the disease occurs, the better the outlook. There is a group of cases, occurring chiefly at the high age of 10-12 years, in which the prognosis is particularly bad (in this variety often only half the head dies). The cases occurring in infancy after reduction of congenital hip dislocation have a very good prognosis.

have very occasionally been cultured, infection is an unlikely explanation, because most patients are quite fit and the bone changes are not like those of an infection.

OTHER THEORIES — A constitutional disorder has been suggested because the condition appears to occur in boys who are growing too slowly, and because there may be a small hereditary factor. Metabolic disturbances, endocrine imbalance, aseptic emboli and localized dystrophy have been incriminated without evidence.

PATHOLOGY

The pathological process takes 2½–4 years and can be conveniently studied in serial x-rays. The changes are primarily in the femoral head but there are often changes in the acetabulum which are thought to be secondary.

FEMORAL HEAD DIES (AVASCULAR NECROSIS) — As a result of death of the femoral head the following changes occur. It appears more dense on x-ray; the increased density may at first appear diffusely granular; later, scattered areas or the entire head look uniformly dense.

Dead bone does not grow, therefore the head becomes flat, and on x-ray the joint space is increased (cartilage is nourished by synovial fluid and continues to grow).

Dead bone crumbles and crushes easily; consequently the flattening is increased and fragmentation also occurs.

THE DEAD HEAD IS REPLACED (CREEPING SUBSTITUTION) — Blood vessels grow in through the neck; the metaphysis, being hyperaemic, becomes soft and looks rare on x-ray. The soft bone squashes easily (hence the thick neck) and bends easily (hence the slight coxa vara). Possibly localized hyperaemia explains the occasional cystic appearance in the metaphysis.

When the blood vessels reach the femoral head, the dead bone is absorbed piecemeal. The bone therefore appears rarefied (in patches or all over). While soft the head may flatten further. Eventually new bone of normal density and architecture is deposited, but the head remains permanently flat.

SYMPTOMS

There are no general symptoms. The local symptoms are limp and aching which are slight, and often intermittent. There is a striking contrast between the paucity of symptoms and the gross changes seen on x-ray.

SIGNS

The usual age is 5–10 years (rarely 2–18 years). The patient is nearly always fit, though slight pyrexia occasionally occurs early in the disease. The condition is 4 times commoner in boys and is sometimes bilateral. The local signs are as follows.

LOOK — There may be slight wasting and trivial shortening, but often the appearance is almost normal.

FEEL — The great trochanter is only slightly elevated and is more prominent than on the normal side *The neck may feel slightly thick*

MOVE — If the patient is seen early in the disease, the hip is irritable and all movements

are slightly diminished. Usually, however, there is no irritability; abduction, especially in flexion, is nearly always diminished and so is internal rotation. Other movements are usually full and painless.

X-RAY — From the outset, the joint space is increased and the head "stands away" too far laterally. Early in the disease the density of the head is slightly increased in a granular fashion. Later there is much more obvious increase of density and it is patchy. The head becomes flattened and fragmented. The neck becomes wide and often shows a band of rarefaction at the metaphysis. The acetabulum may show areas of altered density which are probably secondary.

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TREATMENT

The patient must be kept in bed with skin traction to the leg as long as the hip remains irritable. While waiting for irritability to subside the patient is investigated to exclude tuberculosis (*see* page 28).

Once irritability has subsided the aim of treatment is to prevent weight bearing and thereby to diminish the degree of deformation of the femoral head. Almost all authorities hold this view, but opinions differ as to how weight relief is best enforced. Two facts should be borne in mind: (*a*) the head remains "plastic" for two or three years; and (*b*) the prognosis appears to be the same whatever method of weight relieving is used.

Hence, keeping the child in bed on traction, or even on a double abduction frame (which in theory allows the femoral head to sink back into the acetabulum), seems too drastic. Simpler methods which permit ambulation (such as a weight-relieving caliper or slinging the affected leg from a collar and using crutches) appear adequate.

SEQUELS AND PROGNOSIS

The sequel to pesudocoxalgia is early osteoarthritis. Weight bearing while the femoral head is still soft, by increasing bone deformation, is likely to result in earlier or more severe osteoarthritis; but however gross the deformation, once irritability has subsided there are never any symptoms until adult life.

Age, however, is the most important factor in prognosis. The earlier the disease occurs, the better the outlook. There is a group of cases, occurring chiefly at the high age of 10–12 years, in which the prognosis is particularly bad (in this variety often only half the head dies). The cases occurring in infancy after reduction of congenital hip dislocation have a very good prognosis.

SLIPPED EPIPHYSIS

In adolescents the upper femoral epiphysis may become displaced at the growth disc, resulting in coxa vara. This condition is termed "slipped epiphysis". The slipping occurs gradually (chronic type) in 70 per cent of cases, and suddenly (acute type) in 30 per cent. The cause and pathology are similar in both varieties, but the two types merit separate clinical description.

CAUSE

A slipped epiphysis to some extent resembles a pathological fracture. Trauma may be the precipitating cause, but an underlying abnormality (vaguely postulated as "endocrine") predisposes to slipping.

TRAUMA — *This is undoubtedly a factor because (a) there is often a history of hip "sprains"; (b) sometimes a gross slip is seen immediately following a fall*; and (*c*) during growth the femoral growth disc becomes increasingly oblique, and is thus more liable to displacement with injury.

UNDERLYING ABNORMALITY — *An underlying abnormality is strongly suggested because* (*a*) the slipping occurs gradually in 70 per cent of cases; (*b*) it often becomes bilateral and the second side may slip even while the patient is in bed undergoing treatment for the first; and (*c*) the disorder occurs just before puberty, many of the patients show evidence of endocrine imbalance and the pituitary fossa on x-ray is sometimes small.

PATHOLOGY

The nature of the underlying abnormality is not known with certainty. The following hypothesis seems a likely one.

Shortly before puberty, growth hormones stimulate the growth disc to produce much additional cartilage in preparation for the prepuberty growth spurt. The sex hormones normally play a part in converting this additional cartilage to bone; if they fail to keep pace, *there is too much unossified cartilage which is unable to resist the stress imposed by the increase in body weight. Consequently*, during walking and standing, the shaft of the femur will tend to drive upwards, and when the patient is lying in bed, the weight of the leg will tend to make the shaft roll outwards.

GRADUAL SLIP

SYMPTOMS

Even with "gradual slip" there is a history of injury in half the cases. Pain, usually in the hip but sometimes referred to the knee, is often the presenting symptom. It is regarded as a sprain; *often, and unfortunately, it is disregarded. It soon disappears only to recur* with further exercise. Limp also occurs early and is more constant.

GENERAL SIGNS

The disorder is slightly commoner in boys than in girls. In boys the average age of onset is 15 years, in girls it is 12 years, and it is rare after menstruation has started.

In two thirds of cases the patients are unduly fat and sexually underdeveloped; the other third may be tall, thin and sexually normal.

LOCAL SIGNS

LOOK — In the earliest stage the appearance is normal, but the patient is rarely seen until significant slipping has occurred and deformity is perceptible. The leg is externally rotated and is half to one inch short. Slight wasting is not uncommon.

FEEL — The great trochanter may be higher and more posterior than that of the unaffected hip.

MOVE — The joint is sometimes irritable with a little diminution of movement in all directions, but the most constant and diagnostic limitations are of abduction and internal rotation. The more definite the slip, the more are these two movements limited, and they may be absent.

Muscle bulk is often reduced and a Trendelenburg sign and limp may be present.

X-RAY — In the antero-posterior view, even when slipping is trivial, changes are apparent. The growth disc is too wide and too "woolly" on its metaphyseal side. A line drawn along the superior surface of the neck remains superior to the head instead of passing through it (Trethowan's sign). With further slipping, the upward displacement of the shaft and neck becomes more apparent.

In the lateral view, deformity is usually obvious from the beginning. The head and neck are angulated on each other so that there is a forward bow.

Preslipping stage — A preslipping stage has been postulated. However, it seems unlikely that the condition could present clinically without slight displacement, and a lateral x-ray shows even the smallest slip.

TREATMENT

The aim of treatment is to *reduce* displacement and to *hold* reduction until the epiphysis fuses.

REDUCE —

Traction — Traction is the safest method, but straight traction is probably of little value and it is necessary to apply the pull so as to overcome the external rotation. Even though reduction is not often achieved, traction is valuable in preventing further slip.

Manipulation — Manipulation under anaesthesia, if forcible, endangers the blood supply to the femoral head. However, allowing the semiflexed limb to rotate inwards gently under its own weight is probably safe and sometimes effects reduction.

Operative reduction — Operative reduction is, on the whole, dangerous. Cervical osteotomy has been used, but most British surgeons emphasize the danger of avascular necrosis of the femoral head. Subtrochanteric osteotomy is much safer, but does not provide such perfect reduction.

HOLD —

If traction or manipulation succeeds, the epiphysis is held reduced by internal fixation. Formerly a trifin nail was used but this is being superseded by Moore's pins, which are much finer and less damaging to the blood supply. Internal fixation hastens epiphyseal fusion.

If subtrochanteric osteotomy is performed, the limb is held abducted in plaster until the osteotomy unites. When the plaster is removed, the thigh adducts; the epiphyseal line thus becomes more horizontal and further slipping of the epiphysis is prevented.

SUDDEN SLIP

SYMPTOMS

A definite injury is followed by pain and inability to lift the leg. Often a history of preceding incidents (so-called sprains) can be elicited.

SIGNS

For age and sex distribution and the patient's build *see* Gradual Slip.

The signs in the hip are those of a fractured neck of femur.

LOOK — The leg is short and lies externally rotated.

FEEL — The great trochanter is too high and too posterior.

MOVE — The patient may be unable to lift his leg and passive movements are often painful; when the range can be painlessly tested, abduction and internal rotation are absent.

X-RAY — *Gross displacement at the epiphyseal plate is obvious. The shaft is displaced upwards and rotated outwards. The femoral head is rotated backwards.*

TREATMENT

REDUCE — Whereas traction rarely reduces a gradual slip, it frequently is successful with a sudden slip, and when traction fails, a gentle manipulation under anaesthesia nearly always achieves reduction.

HOLD — Internal fixation with Moore's pins may be performed immediately following reduction. If a Smith-Petersen nail is to be used its insertion should be postponed for 4 weeks; otherwise the nail, as it impinges on the femoral head, is liable to displace it.

SEQUELS TO SLIPPED EPIPHYSIS

COXA VARA — *If displacement has not been reduced, the epiphysis fuses in its deformed position* The patient limps, but the *condition is painless until osteoarthritis* later *develops.* The leg is short and *externally rotated, the trochanter is too high* and too posterior and abduction and internal rotation remain permanently limited, whereas adduction and external rotation may be greater than normal A Trendelenburg sign and limp are often present. X-rays show the coxa vara, often with a downward "step" from the femoral neck on to the head

Subtrochanteric osteotomy should be performed to relieve symptoms and in the hope of preventing *osteoarthritis.*

AVASCULAR NECROSIS — *Death of the femoral head is an important complication.* It is said to occur in one third of those cases in which manipulation has been followed by the insertion of a Smith-Petersen nail, and in the same proportion when cervical osteotomy has been performed. Avascular necrosis is rare if manipulation is avoided and if Moore's pins are used in preference to a Smith-Petersen nail

OSTEOARTHRITIS — Early osteoarthritis is a likely sequel if displacement has not been reduced, and inevitable if there has been avascular necrosis.

BILATERAL SLIPPING — The parents should be warned that, at 6–24 months after a slipped epiphysis, slipping may occur at the other hip. This happens in 15–30 per cent of cases and is commoner in patients with endocrine abnormality.

COXA VARA

In coxa vara the angle between the neck and shaft of the femur is diminished. The normal angle is 160 degrees in a child, gradually decreasing to 130 degrees in adult life.

VARIETIES

CONGENITAL (INFANTILE) — The epiphyseal line is too vertical; with stress the shaft inevitably rides up as far as it can. The process is gradual and painless. The condition presents as a short leg in infancy and is distinguished clinically from congenital dislocation by the fact that the head is in the socket, a finding which is confirmed by x-ray. Subtrochanteric osteotomy is necessary. If bilateral, the condition may not be seen until a young adult presents with osteoarthritis.

ACQUIRED — Coxa vara can develop only if the neck bends (because it is soft) or if it breaks.

Bone softening — Bone softening may produce coxa vara in children (rickets, bone dystrophies and possibly pseudocoxalgia); in adults (osteomalacia); and in the elderly (osteoporosis and Paget's disease)

At any age, tuberculosis or pyogenic infection may soften bone and lead to coxa vara, but the deformity is overshadowed by the causal condition.

Fracture — Fracture may produce coxa vara in children (through a solitary cyst); in adolescents (slipped epiphysis); and in the elderly (mal-union of a trochanteric fracture).

OSTEOARTHRITIS

(*See also* pages 36–39)

Osteoarthritis, the commonest hip disorder arising in adult life, is painful and disabling.

CAUSES

General causes (old age and obesity) are of little importance. Local lesions are, however, important. Disturbance of the congruity of the joint surfaces, or of the blood supply to the femoral head, or damage to the articular cartilage, is likely to produce *osteoarthritis in a relatively young adult.* Predisposing factors therefore include the following conditions.

Injury, especially to the neck of the femur.

Incongruity, especially resulting from congenital subluxation or from coxa vara.

Inadequate blood supply, as in pseudocoxalgia and after fractures or dislocations.
Inflammation, such as rheumatoid arthritis, in which osteoarthritis may later supervene.

In many cases, no predisposing cause is found.

PATHOLOGY

This is described in detail on pages 36-37, but may be summarized as follows.

CARTILAGE — Articular cartilage at the pressure area (top of the femoral head and acetabular roof) is worn away, becoming thin and rough. At the non-pressure area it becomes thicker.

BONE — Bone at the pressure area becomes dense, hard and sclerosed; cysts may appear in the femoral head. At the non-pressure areas the thickened cartilage may ossify, giving lipping and osteophytes.

CAPSULE — The capsule becomes thick and fibrosed. The hip is an "extreme-range" joint and, as the fibrous tissue shrinks, extension and abduction (which are needed in walking) are soon restricted. Symptoms therefore appear early and, because the necessary movements are continually forced, small tears occur. These heal with more fibrosis which leads to further shrinkage, so that symptoms often progress rapidly.

OTHER TISSUES — Some synovial hypertrophy may occur, but there is seldom excess fluid; some muscle wasting is usual.

SYMPTOMS

Pain radiates from the groin to the knee. At first it occurs when movement follows a period of rest, and after over-use. Later pain is more constant and more severe, and sometimes disturbs sleep.

Stiffness at first is also noticed only after rest. Later it progressively increases. The patient experiences difficulty in putting on socks and shoes.

Limp is an early symptom.

Deformity is sometimes noticed by the patient, who says his leg is getting shorter.

"Giving way" may be a symptom if the patient experiences a twinge of pain when he gets up from the sitting position.

SIGNS

The patient is fit in himself and, unless there has been previous hip disorder, is aged over 50 years when first seen.

LOOK — The leg lies externally rotated and appears short because of fixed adduction. There is also fixed flexion.

FEEL — The great trochanter is slightly elevated and too posterior

MOVE — Movements are diminished, but within a limited range are painless. The restriction is asymmetrical: abduction, extension and internal rotation are lost early and are the most restricted; their opposites are lost late and are less restricted.

Muscle wasting (chiefly of the glutei) is detectable but usually not severe.

True shortening is slight, but apparent shortening amounts to an inch or two

X-RAY — At the pressure area (superiorly) the joint space is decreased and the bone

sclerosed. Elsewhere the joint space is not decreased, but lipping and osteophytes may be seen. There may also be cysts in the femoral head and thickening of the under side of the neck. The amount of pain cannot be gauged from the x-ray appearance.

CONSERVATIVE TREATMENT

The many possible methods of treatment are discussed on pages 38-39 where they are grouped under three principles: (*a*) deal directly with the pain; (*b*) deal with the capsule from which the pain chiefly arises; (*c*) diminish the load on the joint.

The patient is advised to regulate his life within the limits imposed by his hip, and to diet if overweight. He is given analgesics, a raised heel to permit walking without strain on a flexed hip, and a walking stick which enormously reduces the load on the hip. Warmth is soothing and may be applied by wearing a flannel bandage in the form of a spica, by using a hot-water bottle or electric pad at night, and by rubbing in liniments. A physiotherapist may give radiant heat or short-wave diathermy and apply faradism to weak muscles.

Methods occasionally of value are injections of local anaesthetic with hydro-cortisone into the joint, manipulation under anaesthesia (especially for early cases and often combined with injection), or a course of radiotherapy.

OPERATIVE TREATMENT

Operation is indicated only if the patient, in spite of conservative treatment, is unable to work, to sleep in comfort, to walk moderate distances, or to enjoy his leisure. There are three main operations.

OSTEOTOMY — Osteotomy is a good operation because it reduces pain, decreases deformity, and allows some movement to be retained. The femur is divided just below the great trochanter and the shaft abducted, brought to neutral rotation, and its upper end shifted medially. It may then be held in plaster in the corrected position, but to obviate the danger of knee stiffness, internal fixation of the osteotomy is often preferred.

ARTHRODESIS — Arthrodesis is the only certain way to relieve pain permanently but is not easy to achieve. It is the best operation providing the "compensating" joints (lumbar spine, knee and opposite hip) are fully mobile. The essential is to remove articular cartilage from the femoral head and acetabulum; most surgeons then fix the hip in its corrected position with a trifin nail and apply a long hip spica of plaster until the joint is arthrodesed. In the Pyrford arthrodesis, after removing cartilage, the hip is pinned in its adducted position, and deformity corrected by a subtrochanteric osteotomy (*see* page 104).

ARTHROPLASTY — Arthroplasty is theoretically the ideal treatment, but relief of pain is often uncertain or temporary; moreover some instability may result. Its main indication is therefore in bilateral hip disease or when the knee or back have limited movement. The joint is dislocated and the capsule excised. The acetabulum is deepened and the head reamed until it is smooth. To prevent these surfaces adhering, a metal cup is inserted. If, while the head is being refashioned, much of it has to be removed, it is better excised altogether and replaced by a metal prosthesis.

EXPOSURE OF THE HIP —

Smith-Petersen approach — The patient lies on his back with a small sandbag under the affected buttock and a large one under the knee. The skin is incised from the anterior superior iliac spine upwards along the iliac crest for one third of its length, and downwards for 5 inches towards the lateral side of the patella. The deep fascia is incised in the same line. The abductor muscles are detached from the lateral aspect of the iliac crest and the abdominal muscles from its medial aspect. From both aspects the muscles are separated subperiosteally by gauze dissection and a pack is left in to control oozing The plane between the sartorius muscle medially and the tensor fascia lata laterally is deepened, preserving the lateral cutaneous nerve of the thigh. Retracting these muscles exposes the rectus femoris on the lateral side of which a leash of circumflex vessels is divided between ligatures. The rectus is then detached from the anterior inferior iliac spine and retracted medially with the psoas, exposing the hip capsule. To expose the femoral head, the capsule is incised parallel to the neck. If dislocation is required, the capsule is divided in front and the femur rotated laterally.

Lateral approach — The patient lies on the unaffected side with the affected hip and knee slightly flexed. The skin is incised from the great trochanter downwards along the femur for 6 inches, and upwards in the same line to the iliac crest. The ilio-tibial tract is divided in the line of the incision, and the division continued upwards to separate the gluteus maximus muscle from the tensor fascia lata. These muscles are retracted to expose the great trochanter, above which is the gluteus medius and below which is the vastus lateralis The glutei are cut off the trochanter and retracted upwards, exposing the hip capsule.

An improved modification (McFarland) is to chisel off a thin superficial slice of the trochanter, to peel the origin of the vastus lateralis muscle off the femur, and to pull the whole of this continuous sheet (vastus lateralis, trochanter and gluteus medius) forwards. The gluteus minimus is then split and divided; by retracting it upwards the capsule is exposed. This method permits accurate and secure closure.

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CHAPTER 19

THE KNEE JOINT

EXAMINATION OF THE KNEE

BOTH knees must always be compared, and a man must have his trousers, shoes and socks off. It should always be remembered that pain in the knee may be referred from the hip. Like the hip, the knee is examined in three distinct stages.

SYMPTOMS

The five common symptoms are pain, swelling, stiffness, mechanical disorders (such as locking, giving way, clicking), and limp.

SIGNS WITH PATIENT LYING ON HIS BACK

LOOK

Skin — The colour of the skin and any sinuses or scars are noted.
Shape — Wasting, swelling or lumps are observed.
Position — The knee may be held flexed, or there may be valgus or varus deformity.

FEEL

Skin — Increased warmth is detected either by comparing the two knees or, better, by noting the temperature gradient of the affected limb (*see* page 2).
Soft tissues — Any swelling or lumps must be examined. Swelling of the suprapatellar pouch may be due to fluid (when fluctuation and a patellar tap can be elicited); or blood (which has a doughy feel), or thickened synovial membrane (the edge of which is easily palpated). The bulk and tautness of the quadriceps muscle are estimated and, if necessary, the circumference of the two thighs is compared (*see* page 3).
Bones — To identify the bony points and to localize tenderness, the knees should be flexed, if possible to 90 degrees. The joint is then palpated systematically with both thumbs: first the femoral condyles, then the tibial condyles and joint line, and finally the ligamentous attachments

MOVE

Flexion and extension — Normally the knee flexes until the calf meets the ham, and extends completely with a snap, even slight loss of extension, or "springiness" on attempting it, is important.
Abduction and adduction — These movements are virtually absent with the knee straight. Any laxity or pain on attempting angulation is noted.
Rotation — This is tested first with the patient's hip and knee flexed to 90 degrees and

with one hand steadying and feeling the knee, and the other rotating the foot; rotation is then repeated with the knee in varying degrees of flexion. In McMurray's test, the knee is rotated in varying degrees of flexion while being subjected to an abduction force. There may be pain, or a click, or the cartilage may be felt to protrude.

Antero-posterior glide — The patient's hips are flexed to 45 degrees and his knees to 90 degrees. The surgeon stabilizes the limbs by sitting on the patient's feet and with both hands attempts to move the tibia backwards and forwards.

SIGNS AT PATELLOFEMORAL JOINT

This joint is more often at fault than is commonly supposed. It is worthwhile devoting special attention to it while the patient is still lying on his back.

LOOK — The appearance is usually normal.

FEEL — The size, shape and position of the patella are noted. Sometimes there is tenderness around the edges of the patella and a small portion of the articular surface can be readily felt if the patella is pushed laterally.

MOVE — With the knee straight and the patella compressed against the femur, the patella is moved from side to side and up and down. Any grating or pain is noted.

The "apprehension" test is tried. With one hand the patella is pushed laterally while the other hand is used to flex the patient's knee. If the patient has recurrent dislocation, this movement is vigorously resisted.

SIGNS WITH PATIENT LYING ON HIS FACE

LOOK — Scars or swellings are noted.

FEEL — Any lump is palpated.

MOVE — The knee is flexed to 90 degrees and rotated while a compression force is applied; this, the grinding test, reproduces symptoms if a meniscus is torn. Rotation is then repeated while the leg is pulled upwards with the surgeon's knee holding the thigh down; this, the distraction test, produces increased pain only if there is ligament damage (Apley).

X-RAY

Antero-posterior, lateral and sometimes patellofemoral views are required. As usual, the x-ray appearances are noted in an orderly sequence.

(1) The general bone density of the two limbs is compared. (Where an inflammatory lesion is suspected, the antero-posterior views of both knees must be taken on one x-ray plate.)

(2) The joint position is usually normal, but the joint space may be narrowed in some part (including the patellofemoral section) and the joint line may be eroded. Any intra-articular loose bodies should also be noted (a fabella lying behind the joint is often confused with a loose body).

(3) The individual bones and their component parts are examined.

DEFORMITIES OF THE KNEE

KNOCK KNEE (GENU VALGUM)

CAUSES

The causes are as follows.

SOFT BONE — Rickets (especially delayed rickets or renal rickets), rare dystrophies and dysplasias.

BROKEN BONE — Mal-united fracture of the lateral tibial condyle and epiphyseal injuries.

STRETCHED LIGAMENT — The medial ligament may be stretched in Charcot's disease, in paralysis (for example, in poliomyelitis) or where there is fixed adduction of the hip. Valgus deformity can also follow complete rupture of the medial ligament.

IDIOPATHIC — This is much the commonest group. So common is idiopathic knock knee in children that it may almost be considered normal.

GENERAL SIGNS

AGE — Idiopathic knock knee usually appears at the age of 2–3 years, often in children who are slightly overweight, and nearly always recovers by the age of 6 years. In renal rickets the deformity often develops rapidly in adolescence.

GENERAL EXAMINATION — Children with idiopathic knock knee may have other postural deformities (such as a flat foot), but are otherwise normal. It is unsafe to diagnose idiopathic knock knee if the child is abnormally short or there is other evidence of bone dystrophy.

LOCAL SIGNS

LOOK — The patient is supine and the surgeon holds the legs. They are rotated until the patellae face the ceiling and brought together until the inner sides of the knees touch each other. The distance between the malleoli is then measured. If the knock knee is obviously unequal on the two sides, an underlying cause should be sought.

FEEL — Usually no abnormality is felt

MOVE — There is full painless range, sometimes with slight laxity of ligaments and slight hyperextension.

X-RAY — The lower femoral epiphysis may be somewhat oblique, but unless a bone dystrophy exists, there is no other x-ray abnormality

TREATMENT

IDIOPATHIC TYPE — The child is seen at 3-monthly intervals and progress recorded. The parents should be told that the legs will grow straight; almost invariably the condition requires no treatment Raising the inner side of the heels by an eighth of an inch may help to relieve strain on the ankles and helps to set the mother's fears at rest.

Splints were used extensively in the past Whether worn only at night or continuously, they are ineffective, unnecessary, and psychologically harmful.

In the rare cases of severe deformity persisting after the age of 10 years, correction is possible by (*a*) stapling the inner side of the knee epiphyses (the staples are removed when the knee has grown slightly varus; or (*b*) supracondylar osteotomy after growth is complete

OTHER TYPES — No treatment is needed for post-fracture knock knee. Surprisingly enough, osteoarthritis does not seem to follow

Knock knee due to delayed rickets or dystrophy may require osteotomy but it is important first to exclude renal rickets because operation may provoke a uraemic crisis.

BOW LEGS (GENU VARUM)

CAUSES

SOFT BONE — Rickets may cause bowing of the tibiae. Mild rickets may explain the slightly oblique upper tibial epiphysis which is sometimes present. Paget's disease is a common cause.

BROKEN BONE — Mal-union of a fractured upper third of tibia and epiphyseal injuries are factors.

STRETCHED LIGAMENTS — This occurs in jockeys.

IDIOPATHIC — Some babies are born with slight bow legs, or develop them while wearing napkins. They nearly all grow straight.

SYMPTOMS

Deformity is the only symptom. In women, bow legs are considered ugly. When osteoarthritis supervenes, there is pain.

SIGNS

LOOK — The patient should be lying supine, the knees extended, the patellae facing the ceiling and the medial malleoli touching each other. The distance between the knees can then be measured. (In many children the hips can be rotated inwards more than they rotate outwards; the mother thinks the legs are bowed, but when they are held in neutral rotation, there is no bowing.)

FEEL — Usually no abnormality can be felt

MOVE — There is full painless range, but, in adults who have had bow legs for many years, osteoarthritis is liable to develop.

X-RAY — This may show an oblique upper tibial epiphysis or occasionally evidence of an underlying cause.

TREATMENT

Idiopathic bow legs usually recover, and in any case splints are probably of no value.

If bow legs persist beyond childhood operation is desirable, both for cosmetic reasons and to prevent osteoarthritis. There are two methods: (*a*) closed osteoclasis of the tibia; or (*b*) osteotomy.

SWELLING OF THE KNEE

TRAUMATIC SYNOVITIS

Injury stimulates the synovial membrane to produce excess fluid. When the fluid is synovial, with little or no blood, swelling is rarely obvious until several hours after injury. The patient complains, not only of the swelling, but also of pain and weakness.

SIGNS

LOOK — A swelling extends from the joint into the suprapatellar pouch but not beyond it.

FEEL — The swelling is cold, fluctuant, and often a patellar tap can be elicited.

MOVE — Usually movements are as normal as the quantity of fluid permits. If the injury is recent, muscle tautness is lost.

X-RAY — Fluid in the joint may push the patella forwards so that in the lateral view it is too far from the femur.

TREATMENT

Quadriceps exercises are essential. If the muscles are allowed to waste, the knee loses stability and is easily resprained; a vicious circle is thereby set up.

A crêpe bandage helps to control the swelling and is comforting.

The patient should be up and walking, but may need a back splint until he has regained normal muscle control; that is, until he can lift the straight leg off the bed against resistance.

NON-TRAUMATIC SYNOVITIS

Without injury, the knee may become swollen either gradually or rapidly, and the swelling may be transient, or chronic, or intermittent.

CAUSES

INFLAMMATION — This group includes acute (pyogenic or "transient") and chronic (tuberculous, rheumatoid or syphilitic) inflammation.

DEGENERATION — In this group are osteoarthritis (including patellofemoral osteoarthritis) and Charcot's disease.

DOUBTFUL CAUSES — The doubtful group includes villous synovitis and recurrent synovitis (intermittent hydrops).

SIGNS

There may be general signs of the underlying cause. The local signs, other than swelling in the suprapatellar pouch, vary with the cause.

In acute suppurative arthritis the joint is held flexed, feels hot and tender, movement is prevented by spasm, and the x-ray appearance is at first normal.

In transient synovitis there is slight wasting, a little increased warmth and tenderness, limitation of extremes of movement, and a normal x-ray appearance.

In chronic inflammations due to tuberculosis or rheumatoid arthritis wasting is marked, there may be warmth and tenderness, movement is restricted and x-rays show generalized rarefaction. A syphilitic effusion is painless and often both knees are swollen.

In osteoarthritis wasting is slight, the joint is not warm, tenderness is usually localized, movement limited at extremes, and x-rays show diminution of joint space at the pressure area with underlying sclerosis and often lipping.

In Charcot's disease the joint is grossly swollen and deformed, neither warm nor tender, has abnormal painless mobility and x-rays show bone destruction and calcification in the capsule.

In villous synovitis there is gross synovial thickening, but often no warmth or tenderness, a surprisingly good range of movement and a normal x-ray appearance.

TREATMENT

Treatment is discussed under the appropriate headings.

TRAUMATIC HAEMARTHROSIS

Following severe injury the joint may rapidly fill with blood and synovial fluid. The swelling becomes obvious within an hour or two and there is often considerable pain.

SIGNS

LOOK — The joint is held flexed and the suprapatellar pouch is swollen.
FEEL — The knee feels warm, tense and tender; later it feels "doughy".
MOVE — Movement is painful and restricted and the quadriceps muscle cannot tauten.
X-RAY — There may be a fracture into the joint.

TREATMENT

The joint should be aspirated under rigidly aseptic conditions; if a general anaesthetic is used, more detailed examination for ligamentous injury is possible. A crêpe bandage is applied to control swelling, and the leg is cradled in a back splint.

Quadriceps exercises are practised from the start. The patient may get up when he is comfortable, retaining the back splint until muscle control returns.

NON-TRAUMATIC HAEMARTHROSIS

Haemarthrosis, in the absence of definite injury, is very rare. Osteochondritis dissecans (*see* page 226) can sometimes produce bleeding into the joint.

Following recent bleeding in haemophilia, the joint is swollen and held flexed. It feels warm, tender and "doughy", and movements are considerably limited. If there have been several previous attacks, there is also wasting of muscle, and general rarefaction of bone is seen on x-ray; the local signs thus resemble those of tuberculosis but there is a history of bleeding elsewhere.

TUBERCULOSIS OF THE KNEE

A detailed description of tuberculosis is found in Chapter 4.

PATHOLOGY

The bloodborne infection may settle in synovium or in bone; the metaphysis or epiphysis of the femur or tibia may be affected, very rarely the patella. This early stage may heal by resolution or may progress to arthritis. After arthritis, healing can only occur by fibrosis, and a fairly short fibrous ankylosis is common. As the joint is superficial, sinuses are likely to develop.

SYMPTOMS

Limp and ache are early symptoms; later there is swelling and stiffness with night cries and increasing deformity.

SIGNS IN EARLY ACTIVE DISEASE

Because the joint is superficial, all the signs of an irritable joint can be elicited.

LOOK — The joint is held slightly flexed and is a little swollen; muscle wasting makes the swelling more obvious.

FEEL — The skin feels warm and a little fluid is detectable. The synovial membrane may feel thick and its attachments tender. A bone focus also may be tender.

MOVE — Movement in all directions is slightly limited and attempting to force an extreme of range is painful.

X-RAY — There is general rarefaction but a normal joint space and line. The epiphyses may be enlarged or a bone focus visible.

SIGNS IN LATE ACTIVE DISEASE

LOOK — The joint is flexed and wasting gross. Sinuses may be seen.

FEEL — There is warmth, and the soft tissues feel thick, "doughy" and diffusely tender.

MOVE — Movements are grossly restricted by muscle spasm.

X-RAY — In addition to general rarefaction, the joint space is reduced and the joint line irregular.

SIGNS IN HEALING STAGE

The patient feels well and the joint is no longer painful. There is general evidence of healing (normal sedimentation rate, increase of weight, and so on). The joint feels cool, and is no longer thick or tender. If the disease is arrested early, movements gradually return; otherwise a varying degree of stiffness remains. X-rays show recalcification.

SIGNS IN AFTERMATH

The fibrous joint, being unsound, may increasingly deform, and may give pain from time to time. The leg is always thin and often scarred from old sinuses. It may show a triple deformity—fixed flexion, external rotation and backward subluxation. Movement is usually limited to a few degrees.

DIFFERENTIAL DIAGNOSIS

If treatment is to be effective, tuberculous synovitis must be diagnosed promptly and the most important conditions from which it must be distinguished are transient synovitis and chronic synovitis of rheumatoid type presenting at a single joint. Both are common at the knee; whenever synovitis persists despite rest, or recurs with activity, a diagnosis of tuberculosis must be presumed until excluded by a biopsy of the synovium or inguinal lymph nodes (*see* page 28).

Post-traumatic synovitis is usually easy to diagnose by the history and rapid recovery with rest. A fractured tibial spine, however, may be missed on x-ray and, because swelling and loss of extension persist, may mimic tuberculosis. Osteochondritis dissecans may also present with recurrent swelling, but the resemblance to tuberculosis is slight and the x-ray appearance diagnostic.

Late disease (tuberculous arthritis) is usually easy to diagnose and the differentia-

tion from acute or subacute arthritis and from haemophilic arthritis presents little difficulty (*see* pages 30–31).

TREATMENT

ACTIVE STAGE — Apart from general treatment (*see* page 25), the essentials are:
Rest — A Thomas' bed knee splint is usually used.
Traction — Skin traction is applied and the tapes tied to the foot of the Thomas' splint.
Drainage — A bone abscess in the tibia should be evacuated. In the femur this is less advisable because the joint may become infected by the operation.

HEALING STAGE — If the disease is arrested early, the aim is to regain movement and avoid stress. First, the splint is removed and the patient lies with the leg on traction. Then traction is removed and if all is well the patient gets up. He wears a weight-relieving caliper which is taken off at night and for periods of gentle non-weight-bearing exercises during the day. Finally it may be possible to discard the caliper altogether. Frequent observation is essential.

If the disease is arrested late the aim is stiffness in the optimum position (180 degrees). Traction is removed and the patient gets up in a plaster tube or weight-bearing caliper. Later a removable polythene splint may be substituted.

AFTERMATH — An unsound joint is best arthrodesed. In children, because of the risk of affecting growth, operation is usually postponed until growth is almost completed. Arthrodesis is necessarily intra-articular and nowadays Charnley's compression technique is used.

Charnley's compression technique — The synovium and patella are excised and the bone ends sawn across. Steinmann pins are inserted transversely into the femur and tibia and the skin sutured. The pins are connected at their outer ends by clamps which are tightened firmly to compress the bone ends together. A protective plaster back slab is usually added The clamps are tightened daily. After 4 weeks the pins are removed and a plaster tube applied. At 3 months union is sufficiently sound for splintage to be no longer necessary

LIGAMENT INJURIES

CAUSES

ABDUCTION INJURY — An abduction injury to the straight knee may tear the medial ligament, usually at its upper end. The tear may be partial, in which case the untorn fibres act as a splint and spontaneous recovery is likely; or complete, when a torn edge may be folded into the joint.

ADDUCTION INJURIES — Adduction injuries to the straight knee may produce a partial or complete tear of the lateral ligament, usually at its lower end. They are rare because it is unusual for the straight knee to be subjected to an adduction force.

FORCED HYPEREXTENSION — The anterior cruciate ligament may be torn by forced hyperextension, or by severe abduction (which also tears the medial ligament). The posterior cruciate ligament is torn when the tibia is forced backwards while the knee is bent. Both cruciates may be torn in a dislocation.

SIGNS

LOOK — The joint is swollen and held flexed.

FEEL — There is fluid and sometimes the slight warmth and "doughy" feel of a haemarthrosis. Tenderness is most marked over the actual site of the tear; that is, 1 inch above the joint on the inner side with medial ligament tears, just above the head of the fibula with lateral ligament tears, and diffusely in front with cruciate injuries.

MOVE — With any tear, all movements are at first limited by pain and attempts to reproduce the causal force are painful. The cardinal sign of a complete tear is increased movement (lateral hinge or antero-posterior glide); sometimes this increase can be elicited painlessly, but examination under anaesthesia may be necessary.

X-RAY — The appearance is usually normal but x-ray is essential to exclude a fracture. A ligament, instead of being torn, may have avulsed a flake of bone.

TREATMENT

If there is doubt as to whether the tear is partial or complete, the joint is aspirated and re-examined under anaesthetic.

PARTIAL TEAR — Aspiration is usually unnecessary. A crêpe bandage is applied and the patient is taught quadriceps exercises. He may get up as soon as he is comfortable, continuing exercises until full painless range has returned. A temporary back splint is sometimes necessary.

COMPLETE TEAR — Aspiration under anaesthetic is usually advisable, partly for comfort but also to establish the diagnosis Plaster is then applied from groin to toes with the knee a few degrees flexed. The patient is taught quadriceps exercises and gets up when he is comfortable and has regained muscle control. Quadriceps exercises are practised, and the plaster is removed after 6 weeks with medial ligament injuries and 12 weeks with cruciate injuries. A temporary removable back splint is necessary until full control has been regained.

Operative repair is sometimes worthwhile for a complete tear of the medial or lateral ligaments, especially if it is thought that the torn end may be tucked into the joint. Aftercare is the same as with conservative treatment.

Cruciate ligament tears are difficult or impossible to repair operatively; if the tibial spine has been avulsed, however, it can be reattached.

COMPLICATIONS

Following ligament injuries the knee joint may be too stiff or too wobbly.

TOO STIFF (ADHESIONS) — A partial tear of the medial ligament may be followed by adhesions, in which torn fibres stick to untorn fibres. This occurs if vigorous activity was not encouraged. The patient complains of repeated "giving way" due to catches of pain; he has localized tenderness, and pain on abduction and external rotation. (These symptoms and signs are similar to those of a torn medial meniscus; *see* page 218). The x-ray appearance is normal. Occasionally, after an abduction injury, calcification is seen in the vicinity of the upper attachment of the medial ligament (Pelligrini-Stieda's disease).

Adhesions may be treated by deep transverse frictions, or, if these fail, by restoring full movements under anaesthesia and maintaining them by subsequent exercises.

TOO WOBBLY — A complete tear of the medial ligament may leave an unstable knee, with increased lateral wobble. It is possible to reconstruct a new ligament using the semitendinosus tendon, but this is not always successful, and it is often better to rely on building up the muscles by exercises.

Ruptured cruciate ligaments leave an unstable knee which gives way. Increased antero-posterior glide is the cardinal sign and the femur may jolt forwards over the medial meniscus. (A ruptured anterior ligament gives increased forward glide, and a posterior ligament increased backward glide.) Operative treatment is only of temporary benefit, and it is best to develop the quadriceps muscle and accept the remaining disability.

MENISCUS LESIONS

TORN MEDIAL MENISCUS

CAUSE

The meniscus is split along its substance by a force grinding it between the femur and tibia. This can only occur when (*a*) weight is being taken; (*b*) the knee is flexed; and (*c*) there is a twisting strain.

All three factors must be combined to cause the initial split, and a torn meniscus is therefore common in footballers, miners and carpet layers. Tears can occur with less force in middle life when fibrosis has limited the normal mobility of the meniscus.

PATHOLOGY

The initial split may be in the anterior horn, posterior horn, or of the bucket-handle type. The torn portion, if displaced, may become jammed between the femur and tibia, blocking extension. Further injuries may extend the tear or cause secondary tears. If displacement is recurrent it may lead to osteoarthritis.

A meniscus is avascular and is incapable of repair (unless the tear is peripheral). After excision, partial regeneration may occur, but the new "meniscus" has a blood supply.

SYMPTOMS

An accurate history is all-important and questions should be directed towards discovering (*a*) the precise nature of the initial injury; (*b*) the symptoms occurring with further incidents; and (*c*) the state of the knee in the intervals between incidents.

ORIGINAL INJURY — Only a twisting force to the bent knee while it is taking weight can split the meniscus. Following injury, there is pain on the inner side, sometimes locking and, within a few hours, swelling. Apparent recovery may occur.

FURTHER INCIDENTS — With further incidents the patient may complain that, with relatively little force, the knee periodically gives trouble. With each attack, he may complain of locking (an unreliable symptom, *see* page 218), unlocking (if this occurs suddenly it is pathognomonic of a mechanical block), "something moving" on the inner side, and pain on the inner side, often with a click.

Locking — The term "locking" is unfortunate, because a locked door is immovable, whereas a locked knee will flex but not extend. Moreover, the patient speaks of "locking" when his knee is too painful to move, whereas to the surgeon locking means that extension is blocked mechanically. With a torn meniscus, usually only the last few degrees of extension are prevented.

BETWEEN INCIDENTS — Between incidents, the knee is normal, unless the quadriceps muscle is wasted or a bucket-handle tear is in the intercondylar fossa.

SIGNS

The patient is fit, aged 15–35 years and almost always male. It is unwise to diagnose a torn meniscus in a young girl. "Degenerative" tears occur later.

The local signs depend upon how soon after an attack the patient is seen and whether the joint is still locked.

IF THE JOINT IS LOCKED — The joint is held flexed, but usually only 10–20 degrees. The inner side of the joint line is tender and there is some fluid. Full extension is impossible and if the surgeon attempts to force it, an elastic resistance is felt; flexion, however, is almost full. External rotation is painful.

IF THE JOINT IS NOT LOCKED — If the patient is seen soon after an attack, the signs are the same as when the joint is locked except that the joint is not held flexed and can be fully extended

ONCE AN ATTACK HAS COMPLETELY SUBSIDED — Tenderness and pain on rotation may completely disappear. Diagnosis rests upon the history, aided by special tests; namely, McMurray's test and the grinding test (*see* page 209).

POSTERIOR HORN TEAR — A torn posterior horn rarely causes locking, and presents with a less definite history and less definite signs. Tenderness is more posterior and the special tests often helpful.

X-RAY — The x-ray appearance is normal but films are essential to exclude a loose body.

DIFFERENTIAL DIAGNOSIS

It is first necessary to make sure that (*a*) the lesion is mechanical and not inflammatory; and (*b*) the hip is normal, because hip pain is often referred to the knee. Once these two possibilities have been excluded the diagnosis is from the following conditions.

OTHER CAUSES OF TRUE LOCKING

Loose bodies — The original history is different and the attacks variable in character. A loose body may be palpable and is often visible on x-ray.

Recurrent dislocation of the patella — The locking is more dramatic, occurs with the knee flexed to 90 degrees and throws the patient to the ground. The joint may be tender on the inner side and attempts to reproduce the dislocation cause immediate pain and are strongly resisted by the patient.

Fracture — A fractured tibial spine (*see* page 340) may be missed on x-ray. The joint cannot be fully extended but the history is unlike that of a torn meniscus and tenderness is in front.

ATTACKS OF "PSEUDO-LOCKING"

Ligament injuries — The coronary fibres attaching the medial meniscus to the tibia are often damaged by a twisting injury. If adhesions develop, there are recurrent attacks of giving way, followed by pain and tenderness on the inner side. As with a meniscus injury, rotation is painful; but unlike a meniscus injury the grinding test gives less pain, and the distraction test more pain. Coronary ligament sprains can usually be cured by manipulation followed by exercises.

Chondromalacia patellae — Young adults complain of the knee giving way, especially on stairs, often without any history of injury. Pressing the patella against the femur with the knee straight, then moving it up and down and from side to side, reproduces the pain.

Fat-pad injuries — It is conceivable that an enlarged infrapatellar fat pad or a synovial fringe may become pinched on movement, producing sudden twinges of pain and giving way. Tenderness is not over the meniscus and there may be evidence of osteoarthritis.

TREATMENT

CONSERVATIVE — Conservative treatment is indicated in the following circumstances. (*a*) The patient is seen after the original injury and the joint is not locked. It is then justifiable to hope that the tear is peripheral and can repair. The knee is immobilized at 180 degrees in a plaster back slab for 4 weeks. Quadriceps exercises are practised. (*b*) Attacks are infrequent, not disabling, and the patient is willing to abandon those activities which provoke them.

MANIPULATIVE — Manipulation (if necessary under anaesthesia) is indicated if a joint is locked. The joint is rotated in varying degrees of flexion. Sometimes spurious unlocking is achieved because the torn fragment slips into the intercondylar fossa. Further symptoms are then inevitable.

OPERATIVE — Operation is indicated (*a*) if the joint cannot be unlocked, and (*b*) if symptoms are recurrent. The meniscus should be excised, not only to cure the symptoms, but to prevent repeated damage to articular cartilage.

Technique of meniscectomy — A thigh tourniquet is applied and the patient lies on his back with the knee bent to 90 degrees over the end of the table. The skin incision may be transverse and directly over the meniscus (if the diagnosis is certain) or obliquely downwards and laterally (to avoid the infrapatellar branch of the saphenous nerve) if there is the slightest doubt. The capsule is defined, incised transversely just above the meniscus and its deep layer undercut for ease of suture. The synovium is incised and when the meniscus is seen, the incision is extended transversely just above it. Fluid is mopped away and the joint carefully inspected.

The anterior horn is separated from the tibia by cutting first vertically, then horizontally, and the freed portion held in Kocher's forceps while the anterior attachment to the tibia is cut off. A retractor is placed in the medial side of the joint and the front of the meniscus is pulled laterally. The attachments to the tibia and to the medial ligament are carefully divided under direct vision until the whole meniscus can be displaced into the centre of the joint. The attachment to the posterior tibial spine is then divided, taking care to avoid the cruciate ligaments, and the meniscus is removed. (If the posterior horn is accidentally left behind it can be excised through a separate

posteromedial incision; but the chances of disability following two incisions are as great as if the posterior horn is left.)

For closure, the knee is first straightened, the synovium sutured with continuous catgut (for haemostasis), the capsule with interrupted catgut, and the skin with wire or silk. A pressure bandage is applied and the tourniquet removed. Quadriceps exercises are started next day. Stitches are removed on the tenth day and the patient allowed to get up when he can lift the straight leg against resistance.

OTHER MENISCUS LESIONS

IMMOBILE MENISCUS

Degenerative fibrosis may limit the normal excursion of the medial meniscus on the tibia. The patient, usually aged 40–60 years, complains of aching and sometimes of swelling. The joint is tender over the meniscus and rotation is painful. The condition resembles an early osteoarthritic knee, but the x-ray appearance is normal. Heat, massage and deep frictions sometimes produce relief. Manipulation under anaesthesia accompanied by local hydrocortisone injection often helps. Meniscectomy cures the symptoms but is rarely necessary.

TORN LATERAL MENISCUS

The lateral meniscus is less likely to tear than the medial because its attachments permit freer mobility. An injury is followed by attacks of pain and giving way, but rarely locking. Tenderness is on the outer side and rotation, especially internal, is painful. If the symptoms warrant, the meniscus should be excised.

DISCOID LATERAL MENISCUS

In the foetus the meniscus is not semilunar but disc-like; if this shape persists, symptoms are likely. A young patient complains that, without any history of injury, the knee gives way and "thuds" loudly. A characteristic clunk may be felt at 70 degrees as the knee is bent and at 170 degrees as it is being straightened. The meniscus should be excised.

MENISCUS CYSTS

Pathologically, meniscus cysts resemble ganglia; they are probably benign neoplasms, not, as formerly supposed, degenerative in origin. The lateral meniscus is much more often cystic than the medial. In 50 per cent of cases there is a history of injury, often only minor. The condition may be symptomless or the patient may complain of localized ache, worse after activity. Symptoms may abate for months or years, then recur.

There is a characteristic hard lump on the outer side of the knee. (Medial cysts, when they do occur, are larger and softer.) The lump is usually most easily seen with the knee slightly flexed. Rotation may be painful because there is often a degenerate or torn meniscus. Removal of the cyst alone is often followed by its recurrence. Therefore, if the symptoms warrant, the meniscus is excised at the primary operation.

EXTENSOR MECHANISM LESIONS

STRAINS, AVULSIONS AND RUPTURES

Resisted extension of the knee may tear the extensor mechanism. The patient stumbles on a stair, catches his foot while walking or running, or may only be kicking a muddy football. In all these incidents, active knee extension is prevented by an obstacle. The precise lesion depends upon the patient's age. In the elderly, the injury is usually above the patella; in middle life, the patella (which is merely a sesamoid bone within the extensor mechanism) fractures; and in young adults the patellar ligament ruptures. In adolescents, the upper tibial epiphysis is occasionally avulsed but much more often the lesion is an incomplete avulsion strain.

BELOW THE PATELLA

OSGOOD-SCHLATTER'S DISEASE — This condition is common. Although often called osteochondritis, it is nothing more than a traction injury of the apophysis into which part of the patellar tendon is inserted (the remainder is inserted on each side of the apophysis and prevents complete separation).

Often there is no history of injury and sometimes the condition is bilateral. A young adolescent complains of pain after activity and of a lump. The lump is bony and tender and its situation in an adolescent is diagnostic. Sometimes active extension of the knee against resistance is painful and x-rays may show fragmentation of the apophysis.

Spontaneous recovery occurs and usually it is only necessary to restrict such activities as cycling and soccer. If symptoms persist a plaster tube is applied with the knee straight and is worn for 2 months.

FRACTURE-SEPARATION OF UPPER TIBIAL EPIPHYSIS (page 341) — This condition is uncommon. The displacement must be reduced under anaesthesia and held reduced in a plaster tube with the knee straight for 6 weeks.

AROUND THE PATELLA

Three lesions occur: transverse fracture of the patella; avulsion of the quadriceps tendon; and rupture of the patellar ligament. In all three conditions, the joint is swollen and held slightly flexed; a gap may be palpable and the patient is unable to lift his leg with the knee straight. The essential treatment is repair of the extensor mechanism.

TRANSVERSE FRACTURE OF PATELLA (*see also* page 342) — This is the commonest variety. It is accompanied by rupture of the lateral expansions and occurs in middle life.

The fractured patella may need to be excised for fear of leaving a rough articular surface, but even so, excision is merely an incident in repair. The entire extensor mechanism, including the lateral expansions, must be repaired. After operation the knee is supported in a split plaster tube from groin to malleoli, with the joint at 180 degrees. A few days later the front of the plaster is removed, so that a well fitting slab extending around both sides remains. Gentle active exercises are then started. When the wound has healed, the patient is allowed up, but he must not walk without a supporting back slab until full and powerful active extension has been regained, which usually takes

about 6 weeks. During this time flexion is being regained by active *non-weight-bearing* exercises.

AVULSION OF QUADRICEPS TENDON — Avulsion of the quadriceps tendon from the upper border of the patella occurs in elderly people and is sometimes bilateral. Operative repair is essential and the aftercare is as for a fractured patella.

Sometimes avulsion of the tendon is only partial and no operation is then needed.

RUPTURE OF PATELLAR LIGAMENT — This lesion occurs in young adults. Sometimes the ligament is avulsed from the lower pole of the patella. Operative repair is again necessary and the aftercare is as for a fractured patella.

ABOVE THE PATELLA

RUPTURE OF RECTUS FEMORIS — This lesion occurs at the rectus femoris musculotendinous junction, which is well above the knee. Usually the patient is elderly and, as the tissues are degenerate, suture is not feasible. The avulsed muscle fibres retract and *form a characteristic lump, which becomes more obvious and harder when the muscle* is put into action. Function is usually good, so that no treatment is required.

Occasionally a similar injury occurs in young athletes. If it is diagnosed early, suture is probably advisable, or athletic prowess is likely to be reduced.

RECURRENT DISLOCATION OF PATELLA

CAUSES

POST-TRAUMATIC MUSCLE WEAKNESS — Unless there is underlying abnormality, a traumatic dislocation rarely becomes recurrent. To prevent even this slight possibility, the knee, after reduction, should be rested in a plaster back slab and the quadriceps muscle vigorously exercised.

ANATOMICAL ABNORMALITIES — When there is no history of definite injury a predisposing anatomical peculiarity should be sought, but, contrary to popular belief, this is rarely found.

Abnormal joint angulation — Minor degrees of genu recurvatum may be present so that the fully extended position of the knee is not 180 degrees but 185 degrees. This anomaly is more often found than genu valgum. However, if the knee is valgus the action of the quadriceps muscle does tend to pull the patella laterally.

Abnormal bones — The patella is more liable to slide laterally if it is abnormally small, unduly proximal in position or if the ridge on the lateral femoral condyle is less prominent than normal.

SYMPTOMS

Sudden attacks of locking occur without apparent causal injury. The knee gets stuck in a much more flexed position than with meniscus injuries, and the patient is thrown to the ground. Although dislocation is always to the outer side, the patient often says that the patella displaces medially because the uncovered medial femoral condyle shows as a lump.

Between attacks the patient has no symptoms.

Occasionally a patient says his knee has dislocated for as long as he can remember

(so-called "congenital"), and in such cases it may even remain permanently dislocated.

SIGNS

Young adults, usually females, are affected, and the condition may be bilateral. If the knee is seen while the patella is dislocated, diagnosis is obvious. The signs between attacks are as follows.

LOOK — Usually the appearance is normal, only occasionally is there valgus deformity.

FEEL — The patella may be too small or too high.

MOVE — Full painless range of the knee is present, but one special test is nearly always positive: try to push the patella laterally while flexing the knee; this is painful and is vigorously resisted. (The term "apprehension test" has been coined because the patient *fears that dislocation will recur.)*

After repeated dislocations, moving the patella against the femur may produce painful grating, indicating that chondromalacia (*see* below) has supervened.

X-RAY — The appearance is usually normal.

TREATMENT

The first time a patella dislocates it should be reduced, temporarily rested in a plaster back slab and the quadriceps muscle vigorously and repeatedly exercised.

Once dislocation has recurred, treatment is operative. Gallie advised tightening the medial capsule, and Albee elevated the lateral femoral condyle, but these operations are rarely performed nowadays. There are two operations which give good results.

REALIGNMENT — The patellar ligament with the segment of bone into which it is inserted is freed and reattached further medially and further distally. This prevents dislocation, but if chondromalacia is already present it may progress and subsequent patellectomy will be required.

PATELLECTOMY — The patella is excised and the resulting gap repaired. Chondromalacia is now impossible, but the repaired tendon itself occasionally dislocates, and then subsequent realignment as above is necessary. Either operation is therefore sometimes the precursor of the other.

RECURRENT SUBLUXATION OF PATELLA

Recurrent subluxation of the patella also occurs, and is probably more common than is usually supposed. The apprehension test may be positive, but the condition is difficult to diagnose until chondromalacia supervenes. The treatment is patellectomy.

CHONDROMALACIA PATELLAE

CAUSES

(*a*) Recurrent subluxation or dislocation is known to produce chondromalacia patellae.

about 6 weeks. During this time flexion is being regained by active non-weight-bearing exercises

AVULSION OF QUADRICEPS TENDON — Avulsion of the quadriceps tendon from the upper border of the patella occurs in elderly people and is sometimes bilateral. Operative repair is essential and the aftercare is as for a fractured patella.

Sometimes avulsion of the tendon is only partial and no operation is then needed.

RUPTURE OF PATELLAR LIGAMENT — This lesion occurs in young adults. Sometimes the ligament is avulsed from the lower pole of the patella. Operative repair is again necessary and the aftercare is as for a fractured patella.

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RUPTURE OF RECTUS FEMORIS — This lesion occurs at the rectus femoris musculotendinous junction, which is well above the knee. Usually the patient is elderly and, as the tissues are degenerate, suture is not feasible. The avulsed muscle fibres retract and form a characteristic lump, which becomes more obvious and harder when the muscle is put into action. Function is usually good, so that no treatment is required.

Occasionally a similar injury occurs in young athletes. If it is diagnosed early, suture is probably advisable, or athletic prowess is likely to be reduced.

RECURRENT DISLOCATION OF PATELLA

CAUSES

POST-TRAUMATIC MUSCLE WEAKNESS — Unless there is underlying abnormality, a traumatic dislocation rarely becomes recurrent. To prevent even this slight possibility, the knee, after reduction, should be rested in a plaster back slab and the quadriceps muscle vigorously exercised.

ANATOMICAL ABNORMALITIES — When there is no history of definite injury a predisposing anatomical peculiarity should be sought, but, contrary to popular belief, this is rarely found.

Abnormal joint angulation — Minor degrees of genu recurvatum may be present so that the fully extended position of the knee is not 180 degrees but 185 degrees. This anomaly is more often found than genu valgum. However, if the knee is valgus the action of the quadriceps muscle does tend to pull the patella laterally.

Abnormal bones — The patella is more liable to slide laterally if it is abnormally small, unduly proximal in position or if the ridge on the lateral femoral condyle is less prominent than normal.

SYMPTOMS

Sudden attacks of locking occur without apparent causal injury. The knee gets stuck in a much more flexed position than with meniscus injuries, and the patient is thrown to the ground. Although dislocation is always to the outer side, the patient often says that the patella displaces medially because the uncovered medial femoral condyle shows as a lump.

Between attacks the patient has no symptoms.

Occasionally a patient says his knee has dislocated for as long as he can remember

Infection (possibly due to foreign body implantation) results in a warm, tender swelling. Treatment is by rest, antibiotics and, if necessary, aspiration or incision.

INFRAPATELLAR BURSITIS (CLERGYMAN'S KNEE)

The swelling is on both sides of the patellar ligament, being more distally placed than prepatellar bursitis because one who prays kneels more uprightly than one who scrubs. Treatment is similar to that for prepatellar bursitis. Occasionally the bursa is affected in gout or syphilis.

SEMIMEMBRANOSUS BURSA

The bursa between the semimembranosus and the medial head of the gastrocnemius may become enlarged in children or adults. It presents usually as a painless lump in the midline, more obvious with the knee straight. The lump is fluctuant but the fluid cannot be pushed into the joint, presumably because the muscles compress and obstruct the normal communication. The knee joint is normal. Occasionally the lump aches and if so it may be excised through a transverse incision.

Two other swellings behind the knee may be confused with an enlarged semimembranosus bursa.

BAKER'S CYST — Baker's cyst presents as a fluctuant lump in the midline at or below the level of the joint. It is due to synovial herniation following effusion, so that the joint itself is abnormal.

Usually the joint is osteoarthritic, but other disorders may cause a Baker's cyst. Excision alone is liable to be followed by recurrence and the underlying condition should be treated

POPLITEAL ANEURYSM — This is the commonest limb aneurysm and is sometimes bilateral. Pain and stiffness of the knee may precede the symptoms of peripheral arterial disease so that it is essential to examine any lump behind the knee for pulsation.

LOOSE BODIES

CAUSE AND PATHOLOGY

INJURY — A piece of bone and cartilage may be broken off by a single definite injury. Osteochondritis dissecans (*see* page 226) may be traumatic in origin.

DEGENERATION — In osteoarthritis small osteophytes may break off and in Charcot's disease large loose bodies are common.

INFLAMMATION — Small fibrinous loose bodies may occur in chronic inflammatory conditions (such as tuberculosis), but in these the underlying disorder is the dominant feature.

IDIOPATHIC — A synovial villus may hypertrophy, forming at its tip a fibrous nodule which may calcify and sometimes becomes detached. Occasionally a wide area of synovium is similarly affected, a condition known as chondromatosis, or (if the loose bodies calcify) osteochondromatosis. Numerous nodules and loose bodies develop; as many as 700 have been removed from a joint.

(*b*) In many cases no history of these conditions is obtained and repeated but unrecognized minor injury is blamed.

(*c*) Only occasionally is a single definite injury responsible.

PATHOLOGY

Some areas of the patellar articular cartilage look dull and bluish; they are soft and easily indented with a probe. Other areas show irregular cracks and indentations. Where pieces have broken off ("detritus") the unprotected bone is worn away. "Mirror" lesions are often seen on the femoral condyles. *Osteoarthritis may supervene.*

SYMPTOMS

Only occasionally is there a history of injury. Usually the patient complains of attacks of pain, especially on stairs, and of occasional swelling. Later, the knee *tends to give way, but true locking does not occur unless there are loose bodies.*

SIGNS

Young adults, especially females, are affected.

LOOK — Slight swelling due to fluid may occasionally be seen; otherwise the appearance is normal.

FEEL — *Sometimes there is tenderness of the patellar margin or of its articular surface* (which is not difficult to feel if the patella is pushed laterally).

MOVE — Usually knee movements are full and painless, but when the patella is pressed against the femur and is moved, there is painful grating.

X-RAY — At first the appearance is normal Later the patellofemoral joint space narrows *and still later osteoarthritic changes appear.*

TREATMENT

In mild cases, the patient is advised to avoid violent activity. Physiotherapy is sometimes soothing. Many patients appear to recover.

If symptoms are severe, patellectomy is advisable. There are, however, a number of patients in whom symptoms are not severe enough to warrant patellectomy, but who are not relieved by conservative measures. For these patients, some Scandinavian surgeons have advised shaving the cartilage off the patella until it is smooth, but this operation has found little support in England.

OTHER DISORDERS OF THE KNEE

BURSAE

PREPATELLAR BURSITIS (HOUSEMAID'S KNEE)

An uninfected bursitis is due not to pressure but to constant friction between skin and patella. It occurs in carpet layers and miners but rarely in housemaids, who use vacuum cleaners. The swelling is circumscribed and fluctuant, but the joint itself is normal. Treatment consists of firm bandaging and kneeling is avoided; occasionally aspiration is needed. In chronic cases the lump is best excised.

SIGNS

The patient is fit and aged 15–20 years. (There is a rare familial type in which several joints are involved.)

Soon after an attack of giving way or locking, the signs of synovitis or haemarthrosis are present. In addition, however, there is tenderness localized to the medial femoral condyle which is almost diagnostic.

X-RAY — At first, a fragment of bone is seen to be separated from the rest of the femur by a clear zone. Later, the fragment may be hinged on one side and project into the joint. Still later, there is a loose body, and its site of origin is visible.

TREATMENT

CONSERVATIVE TREATMENT — Conservative treatment is worth trying if x-rays show that the fragment is still in position. Plaster is applied to hold the knee flexed, so that the stresses of weight bearing are transmitted behind the damaged area. After 6 months the plaster is removed and sometimes the knee becomes clinically and radiologically normal.

OPERATIVE TREATMENT — Operative treatment is indicated when the fragment is partially or totally detached. The fragment is removed, soft cartilage overhanging the crater is pared off, and a second fragment sought. (Experimentally attempts are being made to fill the crater with cartilage grafts.)

OSTEOARTHRITIS OF THE KNEE

(*See* pages 36–39)

CAUSES

INJURY — A single injury may occasionally lead to osteoarthritis. However, the oft repeated injury of recurrent patellar subluxation gives rise to patellofemoral osteoarthritis, which is much the commonest variety of osteoarthritis of the knee, and may eventually extend to the remainder of the knee. A loose body also may inflict repeated articular damage

INCONGRUITY — Genu varum often leads to osteoarthritis but valgus deformity rarely does so.

INADEQUATE BLOOD SUPPLY — Osteochondritis dissecans may lead to osteoarthritis partly because the loose body inflicts articular damage and partly because the femoral condyle is irregular.

INFLAMMATION — Osteoarthritis may follow chronic inflammations (such as rheumatoid arthritis) which have damaged articular cartilage.

PATHOLOGY

The process appears to start in the articular cartilage. At the pressure area the cartilage becomes rough, fibrillated and thinned, and pieces flake off; beneath it the bone may be sclerosed. At the non-pressure areas the articular cartilage proliferates and calcifies, giving osteophytes which occasionally break off as loose bodies.

The synovial membrane often proliferates and excess fluid is formed.

SYMPTOMS

Loose bodies may be symptomless. The usual complaint is of attacks of pain and of sudden locking without injury. The joint gets stuck in a position which varies from one attack to another. Sometimes the locking is only momentary and usually the patient can wriggle the knee until it suddenly unlocks.

SIGNS

In adolescents, a loose body is usually due to osteochondritis dissecans, rarely to injury. In adults, osteoarthritis is the most frequent cause; occasionally chondromatosis is a cause.

Only rarely is the patient seen with the knee still locked. Sometimes, especially *after the first attack, there is synovitis or there may be evidence of the underlying* cause. A pedunculated loose body may be felt; one which is truly loose tends to slip away during palpation. Often there are no abnormal physical signs attributable to the loose body itself.

X-RAY — Most loose bodies are radio-opaque. The films also show any underlying joint abnormality.

TREATMENT

A loose body causing symptoms should be removed unless the joint is severely osteoarthritic. Operation should not be lightly undertaken, for the loose body may be difficult to find without wide exposure.

OSTEOCHONDRITIS DISSECANS → Avascular necrosis of a bony seg.

(*See also* page 43)

CAUSE

A segment of bone for no apparent reason undergoes avascular necrosis. Minor trauma (usually unnoticed) is the likeliest cause; thrombosis or embolism of an end artery have been blamed.

PATHOLOGY

The convex lower aspect of the medial femoral condyle is usually affected, rarely the lateral condyle, and still more rarely the patella. An area of softened articular *cartilage together with an underlying ovoid piece of bone becomes demarcated from* the femoral condyle. Later, the segment becomes partly detached and finally broken off to form a loose body (sometimes two or three). A crater remains, at the periphery of which the cartilage is undermined.

SYMPTOMS

The patient may present with intermittent ache, or swelling. Later, there are attacks of giving way, followed by swelling, and the knee is "unreliable"; later still true locking may occur.

SIGNS

The patient is fit and aged 15–20 years. (There is a rare familial type in which several joints are involved.)

Soon after an attack of giving way or locking, the signs of synovitis or haemarthrosis are present. In addition, however, there is tenderness localized to the medial femoral condyle which is almost diagnostic.

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The process appears to start in the articular cartilage. At the pressure area the cartilage becomes rough, fibrillated and thinned, and pieces flake off; beneath it the bone may be sclerosed. At the non-pressure areas the articular cartilage proliferates and calcifies, giving osteophytes which occasionally break off as loose bodies.

The synovial membrane often proliferates and excess fluid is formed.

SYMPTOMS

The patient often presents after a trivial injury. Pain is the leading symptom. It is worse after use or (if the patellofemoral joint is chiefly affected) on stairs. After rest, the joint feels stiff and it hurts the patient to "get going" after sitting for any length of time. Giving way sometimes occurs and, rarely, a loose body may cause locking.

Pain and stiffness tend to increase, though remissions are common. An osteoarthritic knee is liable to sprains, and swells from time to time.

SIGNS

The patient is a fit adult.

LOOK — There may be swelling and slight wasting of the quadriceps muscle. The knee may be held a little flexed.

FEEL — Except during an exacerbation, there is little fluid and no warmth; nor is the synovial membrane thickened. The articular margins may be tender.

MOVE — Extremes of movement are usually slightly limited, and attempts to produce them are painful. If the patella is firmly pressed against the femur and then moved, pain is usually elicited.

X-RAY — The joint space is diminished, either between the patella and femur, or between the medial condyles of the femur and tibia. Lipping and osteophytes are often seen and there may be loose bodies.

CONSERVATIVE TREATMENT

If the pain is not severe or disabling, conservative treatment should be employed. The quadriceps muscles are strengthened by exercises and faradism. In addition, the principles of treatment as described on pages 38–39 are applied in the following manner.

Pain may be relieved by analgesics and warmth (massage, liniments, radiant heat, short-wave diathermy). Injections of Xylocaine and hydrocortisone sometimes help.

The strain on the capsule may be eased by bandaging the joint firmly in slight flexion, or by raising the heel of the shoe. Only rarely will the patient tolerate a back splint or caliper.

The load on the joint may be reduced by a walking stick, and the patient may need to diet.

OPERATIVE TREATMENT

ARTHRODESIS — This is the only certain method of affording complete and permanent relief, but a stiff knee is a great nuisance because the leg sticks out in buses. The operation is therefore indicated only when severe pain in unrelieved by conservative measures A short period in a plaster tube before operation enables the patient to decide if the relief of pain is worth the inconvenience.

"ARTHROPLASTY" — Arthroplasty of the knee is not feasible, but patellectomy is, in effect, an arthroplasty of the patellofemoral joint; and when this section is mainly affected, patellectomy is well worth while.

ARTHROTOMY — This may be necessary if a loose body causes repeated locking. It is probably unwise to do more than remove the loose body, because extensive joint "débridement" is rarely effective.

CHARCOT'S DISEASE (*see also* page 40)

CAUSE

Probably trauma to an insensitive joint is the immediate cause; the underlying cause is nearly always tabes.

PATHOLOGY

Only the pathological changes in the joint are considered.

Destruction of bone is rapid and marked, leading to instability. Loose pieces of bone break off into the joint. There is gross enlargement of the joint, with a thick but grossly stretched capsule, ragged hypertrophy of the synovial membrane, and increased fluid. Large calcified masses form in the capsule.

SYMPTOMS

The onset is usually insidious, but progress is sometimes rapid. Swelling is gross and if it increases rapidly there may be temporary oedema and reddening of the skin. Instability is the most important symptom. Pain is usually absent, though tabetic lightning pains may occur.

SIGNS

The patient is tabetic, and usually aged over 40 years.

LOOK — The joint is enormously swollen, and often grossly deformed.

FEEL — The joint feels like a bag of bones and fluid, but is not warm or tender.

MOVE — Movement is increased and abnormal mobility (such as hyperextension and lateral wobble) is present. The joint can be moved painlessly into almost any position.

X-RAY — The joint is usually subluxed, gross bone destruction is obvious and there are irregular calcified masses in the joint and in the capsule.

DIFFERENTIAL DIAGNOSIS

A grossly enlarged knee, if not due to Charcot's disease, may be due to one of the following conditions.

RECENT INJURY — There is pain, tenderness, and limitation of movement together with a history of injury.

ARTHRITIS — There is pain, tenderness, and limitation of movement but no history of injury.

VILLOUS SYNOVITIS — This condition, also known as pigmented villonodular synovitis, is thought either [illegible] Middle aged patients, es[illegible] ıth knees, sometimes with pain and giving way. Movements often remain surprisingly good (so that synovectomy is only rarely indicated), and there are never abnormal movements. Muscle wasting is slight.

TREATMENT

A caliper is worn because of the instability. A course of penicillin may relieve lightning pains and possibly arrest degenerative changes. Operation is never advised.

Suggestions for further reading

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CHAPTER 20

THE ANKLE AND FOOT

EXAMINATION OF THE ANKLE AND FOOT

THE examination is conducted in three stages.

SYMPTOMS

The most common presenting symptoms are pain, deformity and swelling.

SIGNS WITH PATIENT STANDING FACING SURGEON

It is necessary to have both lower limbs exposed from above the knees.

LOOK — The legs, ankles, feet and toes are systematically inspected. The skin colour is noted and the shape and position of the limbs are compared.
FEEL — Palpation is postponed until the patient is sitting.
MOVE — The patient is asked to walk and the gait is observed, particularly to see whether he avoids taking weight on any part of the foot.

SIGNS WITH PATIENT STANDING WITH BACK TO SURGEON

LOOK — The ankles and heels are inspected for deformity or lumps.
FEEL — The foot is not palpated at this stage.
MOVE — The patient is asked to tiptoe; valgus deformity usually then disappears.

SIGNS WITH PATIENT SITTING OR LYING

The patient is next examined lying on a couch, or it may be more convenient if he sits opposite the surgeon and places his feet on the surgeon's lap.

LOOK — The heel is held square so that any foot deformity can be assessed. The sole and toes should be inspected for callosities.

FEEL — The skin temperature is assessed and the pulses are felt. If there is tenderness in the foot it must be correctly localized, for its site is often diagnostic. Any swelling, oedema or lumps must be examined. Sensation may be abnormal.

MOVE — The foot can be regarded as a series of joints which should be examined methodically, in the following manner.

Ankle joint — With the heel grasped in the left hand and the midfoot in the right, [illegible] ...e tarsus [illegible] and down and from side to side.

Toes — The range of movement at the metatarsophalangeal and interphalangeal joints is tested.

SHOES — The shoe may be deformed or show uneven wear.

X-RAY APPEARANCES

Antero-posterior and lateral views of the ankle joint are examined in the routine way. In addition, it may be necessary to x-ray both ankles in full inversion if recurrent subluxation is suspected.

X-rays of the tarsus and metatarsus are only occasionally helpful.

CLUB FOOT

TALIPES EQUINOVARUS

CAUSE

There are two main factors, dysplasia and abnormal intra-uterine pressure. It seems likely that pressure alone may produce a club foot which is simple to treat, while pressure superimposed on dysplasia produces a variety prone to relapse.

DYSPLASIA — A developmental defect of muscle (myodysplasia) occurring early in foetal life is assumed.

In favour of this view, heredity is sometimes a factor; the affected foot is often smaller and the tibialis anticus muscle appears to be too short. However, the ability to restore the foot to normal if treatment is begun early does not suggest that a primary defect alone is responsible.

PRESSURE — It is assumed that deformity due to a cramped position *in utero* is perpetuated.

In support of this view it is observed that in the first few days of life, the baby's legs can readily be folded up in such a way as to reproduce the position *in utero* in which pressure has deformed the feet ("position of comfort"). Dimples at convexities, presumably due to excessive pressure, are confirmatory. It is, however, difficult to understand why equinovarus deformity persists after pressure is removed, whereas other congenital foot deformities recover spontaneously.

PATHOLOGY

(1) The talus points downwards (equinus), the os calcis faces inwards (varus) and the forefoot is adducted. At first this faulty position may be the only abnormality.

(2) If the condition is untreated, the soft tissues of the calf and the medial aspect of the sole fail to grow normally.

(3) Later still, structural bone changes develop, and the foot does not grow to its normal size. The neck of the talus becomes too long; the os calcis is too small, is tilted downwards, points inwards and faces inwards; and the scaphoid bone lies on the medial aspect of the talus.

SYMPTOMS

Deformity is the only symptom in infancy. Painful callosities develop years later if the deformity remains uncorrected.

SIGNS

Boys are affected twice as often as girls. The deformity is bilateral in one third of cases. Associated congenital deformities are rare. The local signs are as follows.

LOOK — The calf is thin and sometimes the leg is rotated inwards. Equinus deformity is seen at the ankle, varus deformity at the subtaloid joint, and adduction at the mid-tarsal joint.

FEEL — Palpation is of little value.

MOVE — The deformities are fixed and cannot be passively corrected. In a normal baby, even though the feet may lie naturally in an equinovarus position, they can be passively dorsiflexed until the toes touch the front of the leg.

X-RAY — This is of little value in babies. Later it shows the malformation and malposition of the bones.

DIFFERENTIAL DIAGNOSIS

Equinovarus deformity may occur not only in congenital talipes; but also in the following conditions.

POLIOMYELITIS — The foot is cold and blue, and there is usually evidence of paralysis.

SPINA BIFIDA — There may be altered sensation in the foot, and trophic changes. The back must always be inspected in any patient with club foot.

ARTHROGRYPOSIS MULTIPLEX CONGENITA — This is a rare condition in which the muscles are undifferentiated and the skin lacks the normal creases.

TREATMENT

The essentials of treatment are to overcorrect the deformities and to hold the overcorrected position until it is stable. The methods employed, and the prognosis, depend largely upon when treatment is begun: the earlier the better, preferably within 24 hours of birth. Four methods will be described, each suited to progressively older patients.

STRETCHING AND STRAPPING — Up to the age of about 2 months the ligaments can be stretched without anaesthesia. The foot is firmly moulded, correcting (and on subsequent occasions overcorrecting) each deformity systematically so that the foot is in calcaneovalgus position with the forefoot abducted. Correction is held by adhesive strapping, with felt protecting the skin at points of pressure. The process is at first repeated weekly, but later at fortnightly intervals.

Treatment must continue for at least a year or relapse is inevitable. Even when the child begins walking, he must be examined at frequent intervals for several years. Towards the end of the first year it is convenient to strap the feet to a Denis Browne splint, and even after strapping is discontinued it is wise to bandage the feet into the splint each night.

WRENCHING AND PLASTER — Over the age of 2 months, the ligaments cannot be stretched but must be forcibly torn. The child is therefore anaesthetized. The foot is wrenched so as to correct the deformities as far as possible. The correction is held in an above-knee plaster with the knee bent. At weekly intervals a wedge may be cut in the plaster

and a little further correction obtained without anaesthesia. Kite advises that only one aspect of the deformity should be corrected on each occasion. Once overcorrection has been achieved, plaster should be worn for at least 6 months. The aftercare is then similar to that following treatment by strapping. Night splints and prolonged observation are still necessary.

SOFT-TISSUE OPERATIONS — If the previous methods have failed and the patient is less than 5 years old, open division of the contracted soft tissues is necessary for correction. Perkins' operation, which should be performed only by those with considerable experience, is as follows.

Technique — The tendo achillis is elongated. Two incisions are then made on the inner side of the foot, one on each side of the neurovascular bundle. Through each incision soft tissues on the concave aspect of the deformity are divided under direct vision. When the foot easily falls into a corrected position, the skin is sutured and an above-knee plaster is worn for 6 months. After removal of the plaster, a Denis Browne night splint may be worn.

BONE OPERATIONS — Over the age of about 5 years, club foot is always associated with structural bone deformities and correction is impossible without bone carpentry. Nevertheless, bone operations should be postponed until the age of 10 years, for fear that growth of the foot may be inhibited. Over the age of 10 years, therefore, a wedge tarsectomy is performed.

Technique — The foot is approached from the lateral side (the convex aspect of the deformity). The detailed anatomy of the bones and joints is ignored, and wedges of bone are removed until all deformity is corrected. A below-knee plaster is worn for 6 months. Occasionally osteotomy of the tibia is also necessary.

OTHER VARIETIES OF TALIPES

Talipes calcaneus (the foot dorsiflexed) is common and often associated with valgus deformity. The deformity usually disappears spontaneously but, if it is severe or persistent, correction is easily and quickly obtained by manipulation and splintage.

Sometimes the only deformity is an adducted forefoot, which may also be corrected by manipulation and splintage. Operation is not necessary even if correction is not obtained because, when the child walks, an ordinary shoe acts as an effective splint.

THE ANKLE

STIFFNESS

Ankle stiffness may be due to tuberculosis, to other inflammatory conditions, or to osteoarthritis.

TUBERCULOSIS (*see also* Chapter 4)

Tuberculosis begins as synovitis or osteomyelitis. Walking soon gives rise to pain and limp, so that the disease may present before there is true arthritis.

The ankle is swollen and the calf wasted. There is warmth, synovial thickening and limitation of movement. X-rays show general rarefaction, sometimes a bone

abscess or enlarged epiphyses and, when arthritis supervenes, narrowing and erosion of the joint space. Because the joint is superficial, a sinus readily forms.

While the disease is active, in addition to general treatment for tuberculosis, the joint is rested in a split plaster at 90 degrees. If healing occurs before there has been a true arthritis, the patient is allowed up on crutches avoiding weight, and wearing a removable splint which is taken off at night and for gentle exercises. Gradually he resumes weight bearing.

If healing occurs only after there has been articular destruction, the patient may be allowed up in plaster, taking gradually increasing weight, and later the plaster is replaced by a caliper. It is often safer, however, to arthrodese the joint. Nowadays it is hardly ever necessary to amputate the leg.

TUBERCULOSIS OF THE TARSUS — Tuberculosis of the tarsus occasionally occurs; it is usually an osteomyelitis of the os calcis which may discharge through a sinus, or spread to neighbouring joints. The patient presents with limp, ache, swelling and sometimes a sinus. The calf is thin and the tarsus swollen, warm, tender and stiffish. X-rays show general rarefaction and often a ragged abscess cavity. Occasionally a brawny cellulitis develops.

In addition to general treatment the limb is rested in a split plaster until healing occurs. Then the patient gets up in a walking plaster, later replaced by a caliper.

OTHER INFLAMMATORY CONDITIONS

BRODIE'S ABSCESS — This is rare but may be seen, especially at the lower end of the tibia. There are attacks of pain and swelling, during which the ankle may feel warm and be locally tender. X-rays show a rarefied area with a clear-cut edge and surrounding sclerosis. The abscess should be evacuated under antibiotic cover.

RHEUMATOID ARTHRITIS — Rheumatoid arthritis may occasionally present with pain and swelling of one or both feet, either at the ankle or in the tarsus. Other joints soon become involved.

GONOCOCCAL ARTHRITIS — Gonococcal arthritis sometimes occurs in the ankle or subtaloid and midtarsal joints.

OSTEOARTHRITIS

At the ankle, osteoarthritis may be a sequel to one of the following conditions.

INJURY, ESPECIALLY AN IMPERFECTLY REDUCED FRACTURE — If the talus does not fit the mortice accurately, or if its upper surface is not horizontal, osteoarthritis is liable to occur.

LOOSE BODY — This may arise from osteochondritis dissecans of the talus.

HAEMOPHILIA — Recurrent haemorrhage leads to degeneration.

Osteoarthritis of the ankle does not necessarily produce symptoms, because it is not an "extreme range" joint. Only very occasionally is operation (arthrodesis) necessary.

SWELLING

Chronic or recurrent swelling of one or both ankles is common and often defies diagnosis. When the condition is bilateral, disorders of the heart and kidneys must

first be considered. Frequently no cause is found and if the condition occurs young women, so-called lymphatic disorders are often blamed. Unilateral swell may accompany an inflammatory condition or persist after injury, in which case diagnosis is usually obvious.

Treatment by intermittent elevation, massage and elastic stockings is worth tryi

GIVING WAY

Apart from unsuitably high heels, this may be due to recurrent dislocation (sı luxation), adhesions following an ankle sprain, or recurrent dislocation of peron tendons.

These conditions are referred to under Dislocation of the Ankle (*see* pages 349-35

THE HEEL

RUPTURED TENDO ACHILLIS

CAUSE

Probably rupture occurs only if a degenerate (avascular) tendon is injured. T patient is pushing off (running or jumping) but contraction of the calf muscle resisted by the body weight.

SYMPTOMS

The patient feels as if he has been struck just above the heel, and he is unable tiptoe.

SIGNS

The patient is usually in the fifth decade of life. Soon after the tear occurs, a g can be seen and felt 2 inches above the insertion of the tendon. Plantarflexion of t foot is weak and is not accompanied by tautening of the tendon. Where dou exists, Simmonds' test is helpful: with the patient prone, the calf is squeezed; if t tendon is intact, the foot is seen to plantarflex; if the tendon is ruptured the fo remains still.

DIFFERENTIAL DIAGNOSIS

"INCOMPLETE" TEAR — It is doubtful in practice whether the tendo achillis is ever on partially torn However, if a complete rupture is not seen within 24 hours, the gap difficult to detect and, because the patient can use his long toe flexors to stand weal on tiptoe, the correct diagnosis is often missed.

TEAR OF SOLEUS MUSCLE — A tear at the musculotendinous junction causes pain a tenderness halfway up the calf. This recovers with the aid of physiotherapy and raisi the heel of the shoe.

TORN PLANTARIS TENDON — This does not occur.

position and is worn for 6 weeks. A new plaster is then applied with the foot at right angles to the leg, and is retained for a further 6 weeks.

The treatment most certain of success is operative repair of the tendon, followed by application of plaster as already described.

PAINFUL HEEL

The causes of pain in the region of the heel may conveniently be classified according to the age group in which they commonly occur.

CHILDREN

Sever's disease (apophysitis) usually occurs in boys of about 10 years of age. It is not a "disease" but a mild traction injury. Pain and tenderness are localized to the tendo achillis insertion. The x-ray report usually refers to increased density and fragmentation of the apophysis, but this appearance is probably normal and often the painless heel looks exactly similar. The heel of the shoe should be raised a little and strenuous activities restricted for a few weeks.

ADOLESCENTS

In girls of 15–20 years, an os calcis knob (often bilateral) is common. The posterolateral portion of the os calcis is too prominent and the shoe rubs on it, causing pain. If attention to footwear does not help, the knob should be gouged away or removed with bone nibblers.

YOUNG ADULTS

Bursitis just above the insertion of the tendo achillis may result from ill-fitting footwear, especially in young women and army recruits. Localized pain and tenderness occur. Pain is usually relieved by removing the stiffener from the heel of the shoe.

Acute plantar fasciitis is said to occur with acute infection, particularly gonorrhoea. Pain and tenderness are localized to the under surface of the front of the os calcis. The underlying cause should be treated and the painful area protected from pressure.

OLDER ADULTS

"Policeman's heel" is common in men aged 40–60 years. It is sometimes called plantar fasciitis, but neither cause nor pathology is known. The only abnormal physical sign is localized tenderness beneath the os calcis. Pressure on the tender area should be minimized by padding which transfers pressure forward of the tender area. An injection of hydrocortisone occasionally helps. The pain slowly subsides in 6–12 months, but may recur.

A bony spur projecting forwards from the under surface of the calcaneal tuberosity is sometimes seen on x-ray. Even when associated with a painful heel, it probably has no significance.

Post-traumatic pain on the lateral side of the heel is not uncommon after a fractured os calcis.

Paget's disease sometimes affects the os calcis, causing deep seated aching which is resistant to treatment.

CHRONIC BONE INFECTION

At any age, the os calcis may be the site of chronic bone infection. A Brodie's abscess has a well-defined margin with surrounding bone sclerosis, whereas a tuberculous infection shows widespread rarefaction and the abscess margin is ill-defined.

THE ARCH

FLAT FOOT

Of the many foot defects, flat foot is one of the commonest. The body weight is normally transmitted through two columns, with the medial border of each foot raised from the ground like the arch of a bridge. The height of the arch may be normally low or normally high, but the term "flat foot" correctly implies that the apex of the arch has collapsed inwards.

Terminology in flat foot is confused. Thus, the terms "pes planus", "abducted foot", "everted foot" or "pronated foot" are simply anatomical descriptions of what is seen when the arch collapses; the terms "weak", "unstable" or "hypermobile" foot, "postural" or "static" flat foot, and "instability of the longitudinal arch" are descriptions of a common physiological predisposing factor; and terms like "foot strain" and "rigid flat foot" describe sequels to the deformity.

CAUSES

ANATOMICAL — Five groups of anatomical peculiarities predispose to flat foot; their frequent inheritance explains the familial incidence.

Limb rotation — The entire limb may be externally rotated, or the leg only may be rotated from the knee downwards. In either case, the patient stands like Charlie Chaplin and the line of body weight, which should come between the first and second metatarsal bones, falls too far medially. As the body moves forwards its weight therefore tends to make the arch collapse.

Genu valgum — At the knee there may be genu valgum. In this, which is common in children, again the body weight is taken too far medially.

Equinus deformity — At the ankle there may be equinus deformity. If the tendo achillis is short, the foot is unable to dorsiflex above the right angle in walking without the tendon taking a short cut. Consequently the arch collapses inwards. (*Note* — If the foot is flat for any reason, the tendo achillis habitually takes a short cut and may become secondarily too tight.)

Varus deformity — At the forefoot there may be varus deformity; this is sometimes due to a relatively short tibialis anticus muscle, and sometimes to a short or elevated first metatarsal bone. As the weight comes on to the forefoot in walking, the first metatarsal head is forced down from its elevated position onto the ground; the apex of the arch is pushed downwards and inwards, and flat foot results. Once weight is on the foot the obvious deformity is the valgus heel, and the true cause may pass unrecognized unless the foot is correctly examined with the heel held square

Congenital — A congenital variety of flat foot occasionally occurs. The talus points almost vertically downwards and the forefoot is dorsiflexed.

PHYSIOLOGICAL — The bony arch of the foot is potentially unstable. It is bound together by ligaments, but these are capable of resisting short-term stress only; indeed, their main function is to act as sensory end organs, and when they are stretched appropriate muscles are reflexly brought into action. Even an anatomically perfect foot will become rapidly and grossly flat unless there are muscles of good bulk and tone to support it.

Infantile flat foot — Until an infant has learnt to control the balancing muscles, the foot collapses on weight bearing. Sometimes the infantile lack of control persists long after walking, and consequently the foot remains flat for years.

Postural flat foot — The posture of many children is poor. They stand with a thoracic kyphosis, a lumbar lordosis and the pelvis tilted forwards. The gluteal, leg and foot muscles share in the generalized poor muscle tone and flat foot may result.

Middle-age flat foot — In middle age muscles tend to become flabby. The housewife not only stands for long periods of time but is likely to put on weight. She gets less support just when she needs more. Flat foot is one of the results.

Temporary flat foot — During prolonged illness in bed the muscles lose their bulk and tone, and on resumption of weight bearing the feet may rapidly become flat.

PATHOLOGY

THE ALTERED SHAPE — The apex of the arch drops; as it does so it also shifts medially, the heel becoming valgus The collapse of the arch and the medial shift are not isolated movements; they are individual components of foot pronation. Pronation occurs at the subtaloid and midtarsal joints (which are functionally one joint); it is accompanied by abduction of the forefoot.

SECONDARY EFFECTS — (*a*) If the foot flattens rapidly (after prolonged recumbency) microscopic tears of the ligaments result. Consequently pain, tenderness and oedema develop and the condition is known as "foot strain".

(*b*) If the foot has been flat for years, secondary changes develop in the joints, which become osteoarthritic. There is consequent loss of suppleness (rigid flat foot).

(*c*) A flat foot leads to other foot defects: as the arch drops, the forefoot splays out, and becomes wider. With ordinary shoes a hallux valgus deformity is then liable to develop. Moreover, weight taken upon the flattened forefoot squashes the intrinsic muscles, and metatarsalgia and curly toes are liable to occur.

SYMPTOMS

Often there are no symptoms. Those which may occur are grouped under deformity and pain.

DEFORMITY — The mother or the school doctor notices flat feet of which the child does not complain. Sometimes it is the "shoe deformity" which attracts attention; characteristically the upper of the shoe is pushed inwards and the outer side of the heel wears too quickly.

PAIN — Pain in a flat foot may occur for a variety of reasons.

(*a*) Pain in a foot which becomes rapidly flat is due to microscopic ligament tears.

(*b*) Pain in a rigid flat foot is due to osteoarthritis of the joints and to stretching of the fibrosed capsules in walking. Overstretching (and consequent pain) is diminished by wearing rigid shoes.

(*c*) If secondary forefoot deformities have occurred, metatarsalgia, a painful bunion, or callosities on the toes may develop.

GENERAL SIGNS

The patient's general health must be assessed, and the age and physique noted. If the foot changes are severe, a neurological examination is advisable and the back must be examined to exclude spina bifida. It is useful to examine the feet of a child's parents, because flat foot is so often familial.

LOCAL SIGNS

LOOK — The legs are inspected for abnormal rotation and for knock knee. Then the feet themselves are examined; if the arch has collapsed and appears low, the scaphoid tuberosity will also appear unduly prominent in addition to the arch being too low.

The patient is now asked to turn round. In a flat foot the heel is valgus, the tendo achillis angulating laterally near its insertion. The patient should next stand on his toes. Unless the foot is rigid the arch re-forms, the prominent scaphoid tuberosity disappears and the tendo achillis straightens.

The patient now sits, and each foot is examined in turn while the surgeon holds it with the heel square. It is then possible to see if the forefoot is varus and if the first metatarsal bone is short and elevated. The forefoot is also examined for associated disorders.

FEEL — The foot is palpated for tenderness: first under the arch, then at the midtarsal region, and finally at the forefoot.

MOVE — With the heel still held square and the knee straight, movements of the foot are tested. First the ankle: does it dorsiflex above a right angle? If there is a tight tendo achillis, dorsiflexion does not occur without the heel moving into valgus as the tendon takes its short cut. The subtaloid, midtarsal and metatarsophalangeal joints are each examined in turn to determine their range of movement.

TREATMENT

An arch which is merely low should not be called flat and should not be treated. A true flat foot is nearly always treated conservatively, by exercises, supports and, especially in children, alterations to the shoes. Manipulative or operative treatment is very rarely required except for the secondary forefoot disorders. The detailed treatment may be summarized as follows

TREATMENT OF THE ANATOMICAL CAUSES —

Externally rotated feet — These are not amenable to treatment.

Genu valgum — The inner side of the heel should be built up $\frac{1}{8}$ of an inch. It may be an advantage also to prolong the inner heel forwards (Thomas' heel).

Tight tendo achillis — This is most simply treated by raising the entire heel. Repeated stretching is rarely effective. Operative elongation is seldom advisable and certainly not in girls, for it alters the shape of the calf, and they will in any event soon be wearing higher heels.

Varus forefoot — A varus forefoot is difficult to treat, and raising the inner sole merely perpetuates the varus deformity. Raising the inner heel $\frac{1}{8}$ of an inch and the outer sole $\frac{1}{8}$ of an inch may coax the foot to untwist, and a spring built into the shoe possibly augments this effect (Catterall).

It is occasionally helpful to wrench the foot straight and apply plaster for a time before altering the shoes. On the assumption that varus forefoot is the sequel to an elevated first metatarsal, corrective osteotomy (Stamm) has been advised.

TREATMENT OF THE PHYSIOLOGICAL CAUSES —

Infantile flat foot — The necessary balancing reflexes cannot be taught, their development must be awaited with patience and understanding.

Postural flat foot — The general posture can be improved by exercises and training. The best method is to teach the child to twist his knees outwards while keeping the big toes on the ground. At the same time the child stands correctly with his "tail" tucked in. Walking on tiptoe is valueless, and walking on the outer side of the feet may be harmful if the forefoot is varus.

Middle aged flat foot — In addition to carrying out the above exercises the patient should try to lose weight. If possible she should not stand still for long periods of time; walking about is less harmful to the feet and helps by exercising the muscles.

Temporary flat foot — Foot exercises should be practised before the patient gets up after prolonged recumbency. A course of faradic foot baths may be of value.

TREATMENT OF THE PATHOLOGICAL EFFECTS —

Altered shape — The arch may be supported by a valgus insole, which is made of sponge rubber covered with leather and fits into the shoe. It is theoretically possible to correct the deformity at operation and to fuse it in the corrected position, but this is almost never advisable.

Foot strain — If this has not been prevented, the patient should be put back to bed and exercises begun. He gets up for gradually increasing periods wearing a temporary support

Rigid flat foot — A rigid support or a rigid shoe prevents the ligaments from being overstretched. Operative fusion of the joints is possible in theory but in practice is not necessary.

Associated forefoot disorders — Secondary metatarsalgia, bunions and curly toes may all require attention, but the flat foot, which is the primary defect, also requires treatment.

SPASMODIC FLAT FOOT

The peroneal and extensor muscles are in spasm, and the foot appears flat.

CAUSES

ANATOMICAL ABNORMALITY — In 40 per cent of cases there is an abnormal bar of bone, which may join the os calcis to the navicular bone or to the talus.

TRAUMA — A heavy adolescent may repeatedly jar his foot—for example, as he gets on and off a bicycle—and may thus "irritate" the subtaloid joint.

INFECTION — Because the condition resembles an arthritis of the subtaloid joint, infection from a distant septic focus has been postulated ("tonsil foot").

SYMPTOMS

Pain is the presenting symptom; a painful flat foot in adolescence is nearly always a spasmodic flat foot. The parents may notice deformity even if the pain is trivial.

SIGNS

The condition occurs between the ages of 12 and 16 years, is twice as common in boys, and is bilateral in two thirds of cases.

LOOK — The foot is held everted and the peroneal and extensor tendons can be seen standing out in spasm under the skin.

FEEL — There may be diffuse tenderness around the tarsus.

MOVE — Ankle movements are normal. Subtaloid joint movement is grossly restricted and often painful; even if no spasm was previously visible, attempted movement provokes it. Midtarsal movements are also restricted.

X-RAY — An abnormal bar of bone may be seen although special views are sometimes needed to demonstrate it.

TREATMENT

CONSERVATIVE — The patient is put to bed for 3 weeks. A walking plaster is then applied with the foot in its normal position (if spasm has persisted an anaesthetic is necessary). The plaster is worn for at least 6 weeks An outside iron and inside T-strap can then if necessary be worn for a further 3 months.

OPERATIVE — If conservative measures fail a triple arthrodesis permanently relieves pain. It may be, however, that *excising an abnormal bar of bone will relieve pain without* limiting mobility.

PAINFUL FLAT FOOT

Flat foot in adolescents is rarely painful unless it is a spasmodic flat foot. In children, pain in the midtarsal region is even less common. A rare cause is *Köhler's* disease (osteochondritis of the tarsal scaphoid). The bony nucleus of the scaphoid bone becomes dense and fragmented. The child, usually aged about 5 years, has a painful limp, and a tender warm thickening over the affected area. The condition resembles a tuberculous joint, but there is no wasting and movements are full. If the foot is strapped, and activity restricted for a few weeks, symptoms disappear. The foot eventually becomes completely normal clinically and radiologically.

PES CAVUS

CAUSES

MUSCLE DYSPLASIA — If the long toe flexors and extensors fail to grow normally they *bunch the foot up* and claw the toes.

MUSCLE WEAKNESS — The lumbrical and interosseus muscles normally flex the straight toes (that is, they flex the metatarsophalangeal joints and extend the interphalangeal joints). If these short intrinsic muscles are weak, they are overpowered by the long toe muscles and claw foot and curly toes are produced.

The muscle weakness may be due to neurological disease, myopathy or vascular lesions (see Differential Diagnosis). In the majority of cases, however, no cause is found and the condition is termed "idiopathic".

MUSCLE FIBROSIS — A similar deformity may occur if the intrinsic muscles shorten as a result of fibrosis, whatever its cause.

PATHOLOGY

The deformity resulting from muscle imbalance is a complex one. At the subtaloid joint there is inversion of the heel. At the midtarsal joint there is plantaris deformity, that is, the forefoot is plantarflexed, bringing it below its normal level. The metatarsophalangeal joints are hyperextended. The interphalangeal joints are flexed.

After a time these deformities become fixed and the foot takes pressure over too small an area of the sole, where painful callosities develop under the metatarsal heads. There is not enough height in the shoe for the curly toes and callosities develop on their dorsum.

SYMPTOMS

Deformity may be noticed by the mother or the school doctor before there is any pain

Usually, pain is felt at the site of callosities. Sometimes there is also a general aching of the foot and calf after exercise.

The ankle may sprain easily because of the varus heel.

SIGNS

Neurological disease, muscle myopathy or vascular lesions should be excluded. Idiopathic pes cavus is first noticed at the age of 8–10 years in an otherwise fit child. There is often a positive family history and as a rule both feet are affected.

LOOK — The deformities described are obvious. The extensor tendons stand out as tight bands under the skin. Callosities may be visible.

FEEL — The callosities are often tender.

MOVE — The ankle may move normally, but even when it is dorsiflexed the forefoot remains at a lower level than the heel (plantaris deformity). The subtaloid joint is in fixed inversion. The midtarsal joint is in a fixed plantaris position and cannot be dorsiflexed The metatarsophalangeal joints are fixed in hyperextension and are often subluxed or dislocated. The interphalangeal joints are fixed flexed.

X-RAY — There is no abnormality of the individual bones. It may be necessary to x-ray the spine to exclude spina bifida.

DIFFERENTIAL DIAGNOSIS

Before claw foot is labelled as idiopathic the following conditions must be excluded.

TRAUMA — A heavy adolescent may repeatedly jar his foot—for example, as he gets on and off a bicycle—and may thus "irritate" the subtaloid joint.
INFECTION — Because the condition resembles an arthritis of the subtaloid joint, infection from a distant septic focus has been postulated ("tonsil foot").

SYMPTOMS

Pain is the presenting symptom; a painful flat foot in adolescence is nearly always a spasmodic flat foot. The parents may notice deformity even if the pain is trivial.

SIGNS

The condition occurs between the ages of 12 and 16 years, is twice as common in boys, and is bilateral in two thirds of cases.

LOOK — The foot is held everted and the peroneal and extensor tendons can be seen standing out in spasm under the skin
FEEL — There may be diffuse tenderness around the tarsus.
MOVE — Ankle movements are normal. Subtaloid joint movement is grossly restricted and often painful; even if no spasm was previously visible, attempted movement provokes it. Midtarsal movements are also restricted.
X-RAY — An abnormal bar of bone may be seen although special views are sometimes needed to demonstrate it.

TREATMENT

CONSERVATIVE — The patient is put to bed for 3 weeks. A walking plaster is then applied with the foot in its normal position (if spasm has persisted an anaesthetic is necessary). The plaster is worn for at least 6 weeks. An outside iron and inside T-strap can then if necessary be worn for a further 3 months
OPERATIVE — If conservative measures fail a triple arthrodesis permanently relieves pain. It may be, however, that excising an abnormal bar of bone will relieve pain without limiting mobility.

PAINFUL FLAT FOOT

Flat foot in adolescents is rarely painful unless it is a spasmodic flat foot. In children, pain in the midtarsal region is even less common. A rare cause is Köhler's disease (osteochondritis of the tarsal scaphoid) The bony nucleus of the scaphoid bone becomes dense and fragmented. The child, usually aged about 5 years, has a painful limp, and a tender warm thickening over the affected area. The condition resembles a tuberculous joint, but there is no wasting and movements are full. If the foot is strapped, and activity restricted for a few weeks, symptoms disappear. The foot eventually becomes completely normal clinically and radiologically.

PES CAVUS

CAUSES

MUSCLE DYSPLASIA — *If the long toe flexors and extensors fail to grow normally they bunch the foot up and claw the toes.*

SHOES — Shoes cannot, of course, produce metatarsus varus deformity; but, when that deformity is present, they may force the hallux into valgus, because no modern shoe allows the toe to continue along the line of a varus first metatarsal. The importance of footwear in causing hallux valgus is much disputed; its importance in causing the symptoms is undeniable.

PATHOLOGY

The most obvious feature of the deformity is prominence of the first metatarsal head. This undue prominence results from several factors: (*a*) increased width of the forefoot, with the first metatarsal shaft deviated medially away from the second; (*b*) the metatarsal head develops a protective bursa (bunion) where the shoe rubs; and (*c*) the proximal phalanx of the hallux is inclined laterally towards the second toe, which is crowded and may become deformed.

Into the gap between the first and second metatarsal heads, the long tendon of the hallux and the sesamoid bones are shifted laterally; once this shift has occurred, the "bow-stringing" effect tends to increase the toe deformity.

SYMPTOMS

Often there are no symptoms, even with apparently gross hallux valgus. Deformity may be the presenting symptom.

Pain, if present, may be due to (*a*) an inflamed bunion; (*b*) a hammer toe; or (*c*) an associated wide splay foot (with pain under the metatarsal heads).

SIGNS

Hallux valgus is usually bilateral, and is commonest in the sixth decade and in females, especially if they are overweight. There is a variety, strongly familial and by no means uncommon, which presents in adolescents.

LOOK — The forefoot is too wide. The hallux has a varus metatarsal with too prominent a head, over which there is a bursa; and the proximal phalanx is valgus and often rotated. The extensor tendon can be seen standing out as a tight band. The second toe may overlap the first or underlap it, or be a hammer toe. There may be callosities under the metatarsal heads

FEEL — The site of tenderness is important and must be accurately localized, for it may influence treatment.

MOVE — The metatarsophalangeal joint, in spite of deformity, usually has a good range of painless movement

X-RAY — The varus metatarsal bone and the lateral shift of the sesamoid bones are clearly seen

TREATMENT

ADOLESCENTS — Deformity is the only symptom, but the mother is anxious to prevent it becoming as severe as her own. Nothing short of operation can prevent the deformity from increasing.

NEUROLOGICAL DISORDERS — These include poliomyelitis, Friedreich's ataxia and spina bifida. There is other evidence of the cause.

MYOPATHIES — In peroneal muscle atrophy the hands also are clawed.

VOLKMANN'S ISCHAEMIA — In Volkmann's ischaemia of the calf there is a history of injury, and claw foot results from contracture of the muscles.

TREATMENT

Treatment depends upon the age of the patient. In young children, before deformity is fixed, it may be possible to prevent deterioration by exercises and attention to footwear. In adolescents, the deformity should be corrected by surgery. In adults, the bones have become altered in shape and only palliative treatment is advised.

YOUNG CHILDREN — An attempt is made to strengthen the intrinsic muscles by exercises in which the straight toes are taught to flex at the metatarsophalangeal joints. Great care should be taken to see that the shoes are long enough and the heel is low, and the child should wear an anterior platform support.

ADOLESCENTS — Correction of the deformity may be obtained by manipulation or by operation.

Manipulation — The toes are forced straight and the foot wrenched as flat as possible. To aid in flattening the arch, the tissues arising from the os calcis may be divided with a tenotome or (as advised by Steindler) at open operation. The corrected position is held in plaster for at least 6 weeks and appropriate footwear is then worn.

Operation — Operation is more satisfactory. All the interphalangeal joints are arthrodesed (so that the long flexors now flex the toes instead of bunching them up) and the long extensors are reinserted into the metatarsal necks (so that they elevate the forefoot). The principle of this operation was devised by Lambrinudi, but internal fixation with wires is preferred to his method of holding the arthrodesed toes anchored to metal splints. Although the procedure is lengthy, results are excellent.

ADULTS — Palliative treatment is usually all that is practicable in adults. A cork or sponge insole is fitted to distribute pressure evenly, and shoes are made specially. The shoe must be large enough to accommodate the foot, the claw toes and the insole, all without undue pressure. With care and chiropody, any patient can be made comfortable, and only rarely is arthrodesis of the subtaloid and midtarsal joints necessary.

THE HALLUX

HALLUX VALGUS

CAUSES

There are two main factors in the causation of hallux valgus.

VARUS FIRST METATARSAL — A varus first metatarsal may be congenital or acquired.

Congenital — The condition is often familial, and the first metatarsal is rotated (like a thumb), suggesting an atavistic abnormality. Sometimes, however, the valgus deformity of the toe seems to precede the varus position of the metatarsal.

Acquired — In middle age and with increasing weight, the forefoot splays so that the first metatarsal becomes more varus.

SYMPTOMS

Pain on walking, especially on slopes or rough ground, is the predominant symptom.

SIGNS

Adult males are chiefly affected, but the condition also occurs in adolescents of either sex. It is often bilateral.

LOOK — The hallux is characteristically straight and not valgus. The metatarsophalangeal joint is knobbly. Often there is a callosity under the medial side of the distal phalanx. The outer side of the sole of the shoe may be unduly worn.

FEEL — The joint feels knobbly and is often tender, especially on its dorso-lateral aspect.

MOVE — At the metatarsophalangeal joint dorsiflexion is restricted and painful; plantarflexion may also be limited. Sometimes dorsiflexion at the interphalangeal joint is considerably increased; as a result of this compensatory movement there may be no symptoms

X-RAY — In adults the x-ray changes are those of osteoarthritis. The joint space is narrowed, there is bone sclerosis and often considerable osteophyte formation.

TREATMENT

ADOLESCENTS — It is essential for the shoes to fit accurately. A rockered sole usually abolishes pain and is more comfortable than a metatarsal bar; the "rocking-horse" motion of the shoe in walking obviates the necessity for dorsiflexion at the metatarsophalangeal joint.

ADULTS — A rockered sole often affords complete and permanent relief while the adapted shoe is being worn. Only when pain persists in spite of a rockered sole should operation be considered.

Arthroplasty (Keller's or Mayo's operation) often relieves pain but weakens the foot a little.

Arthrodesis abolishes pain and, as the patients are usually men, variations in the height of heel are not required.

Osteotomy of an elevated first metatarsal has been advised for adolescent patients.

Sometimes a mild hallux rigidus is associated with a large exostosis on the dorsum of the first metatarsal head; if this exostosis is troublesome it may be bevelled off.

OTHER DISORDERS OF THE HALLUX

GOUT (*see* page 17)

Gout often affects the metatarsophalangeal joint in men. The patient wakes with acute pain and pyrexia. The joint is swollen, hot and acutely irritable. Other evidence of gout is often found.

CHONDROMALACIA

This is a degenerative condition of the joint between the medial sesamoid bone and the first metatarsal head. There is localized pain on walking, and tenderness. Only if appropriate padding fails to relieve pain should removal of the sesamoid bone be considered.

Reconstruction of hallux — Attempts at radical reconstruction of the hallux, designed to restore the forefoot to normal, are being carried out experimentally. It is possible to correct varus deformity of the first metatarsal by an osteotomy near its base, and to maintain correction by reinserting the adductor hallucis into the metatarsal neck.

ADULTS — All patients with hallux valgus can be made comfortable by careful attention to footwear. The shoe should be wide and the upper soft. Padding may be used to protect the bunion or a hammer toe. Foot exercises and an anterior platform type of support are useful when there is a splay foot with metatarsalgia.

Surgery is only sometimes successful. Operations in adults with hallux valgus are palliative, and are reserved for patients whose symptoms are not relieved by conservative measures.

Arthroplasty — This is the commonest procedure. It relieves pain due to a bunion but not pain under the metatarsal heads. It usually weakens the foot a little.

Keller's operation — The proximal third of the proximal phalanx is excised, and the prominent portion of the metatarsal head trimmed. This is the most popular operation.

Mayo's operation — The metatarsal head is excised and the prominent portion of the proximal phalanx trimmed. In theory this weakens the foot more than Keller's operation but in practice results are the same.

With either Mayo's or Keller's operation it is often wise to elongate the extensor hallucis tendon and to shorten and straighten the second toe. A plaster toecap with the toe joints straight is sometimes applied and removed after 2 weeks. Foot exercises are then necessary, and supports are sometimes advisable.

Arthrodesis — Arthrodesis, when successful, may be relied upon to abolish pain, but does not permit of any variation in the height of the heel worn by the patient.

The articular cartilage is removed, deformity corrected and the bones fixed together with a screw or small compression clamps.

Other procedures —

Bunionectomy — Excising the bunion with the underlying knob of bone is a simple palliative procedure, but symptoms often recur. Slightly better results may follow if the medial ligament is carefully reconstructed after the operation.

Girdlestone's operation — This is a combined arthrodesis and pseudarthrosis. The middle third of the proximal phalanx is excised, and the proximal portion is fused to the metatarsal in a straight position. In theory the adductor hallucis muscle now corrects the varus metatarsal because it is attached to the proximal portion of the phalanx; and movement is retained because of the excision of a portion of the phalanx. In practice, results are no better than those of a Keller's operation.

HALLUX RIGIDUS

CAUSES

CONGENITAL — If the first metatarsal is too short or is congenitally elevated, the metatarsophalangeal joint must be hyperextended to allow the ball of the toe to reach the ground. The joint is therefore constantly in an extreme position and liable to degeneration.

TRAUMA — If the hallux is much longer than the second toe, it is liable to be stubbed repeatedly against the toecap of the shoe; especially when a shoe is too long and so wide that the foot slides forwards in it.

Morton's metatarsalgia — This condition is associated with a painful neuroma on a digital nerve. The neuroma occurs at the level of the metatarsal necks just proximal to the division of the digital nerves of the second or third clefts. Women aged 40–50 years are mainly affected. Sharp intermittent pain shoots into the toes, but is felt only when shoes are worn, possibly because the metatarsal bones are then squeezed together ("compression metatarsalgia"). Tenderness is localized to the neuroma and sensation may be diminished in the affected cleft.

SYMPTOMS

Pain is the symptom. There may also be aching, tiredness or deformity.

SIGNS

The age of the patient may suggest the diagnosis. In young adolescents one thinks of idiopathic pes cavus, or acute hallux rigidus; in young adults, of Freiberg's disease or a stress fracture; and in older people of splay foot, hallux disorders, curly toes or Morton's metatarsalgia.

LOOK — There may be deformities of the foot as a whole or of the individual toes; callosities may be present. It is important to observe the distribution of weight when the patient stands and when he walks.

The shoes also should be inspected: they may be too short or too long, too narrow or too wide. The heels may be of unsuitable shape or height. Uneven wear must be noted.

FEEL — The exact site of tenderness must be found by systematic and careful palpation, which will also disclose the presence of any lumps.

MOVE — The foot joints must be examined for pain or limitation of movement.

X-RAY — Freiberg's disease or a stress fracture may be seen.

TREATMENT

This largely depends upon the cause of the metatarsalgia, but may be summarized in the following manner.

CONSERVATIVE — Pads or insoles are used to take pressure from tender areas. Adequate footwear is provided. Exercises are given to strengthen the foot muscles.

OPERATIVE — In appropriate cases it may be advisable to operate on the hallux or other toes.

If Morton's metatarsalgia does not respond to protective padding, the neuroma is excised through a plantar incision.

If Freiberg's disease remains painful, the metatarsal head is excised through a dorsal incision.

TOE DISORDERS

HAMMER TOE

The metatarsophalangeal joint is hyperextended, the proximal toe joint fixed flexed, and the distal joint extended. The second toe on one or both feet is commonly affected. The toe may have been too long, or the shoes too short, or there may be a hallux valgus.

TOENAIL DISORDERS

The toenail of the hallux may be ingrown, overgrown, or undergrown.

INGROWN — The nail burrows into the soft tissues with a resulting liability to infection. Pain may be relieved by careful trimming, cutting a V in the centre of the nail, and wearing wide shoes. If these fail, partial or complete removal of the nail may be necessary. In recurrent cases it is essential to remove the nail completely and, to obtain satisfactory skin closure, the distal half of the terminal phalanx is removed.

OVERGROWN (ONYCHOGRYPHOSIS) — The nail is hard, thick and curved. A chiropodist can usually make the patient comfortable, but occasionally the nail may need excision.

UNDERGROWN — A subungual exostosis grows on the dorsum of the terminal phalanx and pushes the nail upwards. The exostosis should be removed.

THE METATARSALS AND TOES

METATARSALGIA

This term is used differently by different writers. In its widest sense it simply means pain in the metatarsal region. It is not a disease but a symptom.

CAUSES

Any foot abnormality which results in faulty weight distribution may produce metatarsalgia. The causes are therefore numerous and may be summarized in the following manner.

DISORDERS OF FOOT AS A WHOLE — A splay foot is wide and often associated with a hallux valgus and curly toes It is commonly seen in middle aged women who have put on weight and is in them a frequent cause of metatarsalgia.

A claw foot with claw toes causes pain under the metatarsal heads because weight is taken over too limited an area.

DISORDERS OF INDIVIDUAL TOES — Any of the hallux disorders already described, such as valgus or rigidus, ingrown toenail, and so on, is a possible source of pain, not only at the site of the disorder itself but also in the metatarsal region, because of faulty weight distribution.

If any of the other toes is painful or deformed so that it does not take its proper share of weight, pain under its metatarsal head is liable to occur. Thus, hammer toe, claw toes, and curly toes may all produce metatarsalgia

SPECIAL CAUSES —

Freiberg's disease — This is a "crushing" type of osteochondritis of the second metatarsal head (rarely the third). It affects young adults, usually women. A bony lump (the enlarged head) is palpable, it is tender and the affected joint is irritable. X-rays show the head to be wide and flat, the neck thick, and the joint space increased.

Stress fracture — Stress fracture usually affects the second or third metatarsal. It occurs in young adults after unaccustomed activity. The affected shaft is thick, lumpy and tender. The x-ray appearance is at first normal, but later there is fusiform callus and a fine transverse fracture.

CHAPTER 21

PRINCIPLES OF FRACTURES

THE subject of fractures is simplified if it is remembered that bone does not break in a haphazard manner. The varieties of common fractures are limited and their patterns few.

CAUSAL FACTORS AND MECHANISM OF INJURY

The patient who breaks a bone has been subjected to physical force. For the assessment of a fracture it is valuable to consider three factors: the amount of the force, the direction in which the force was exerted, and the patient's age.

AMOUNT OF FORCE — If the force was insufficient to break normal bone, the fracture is pathological, and further investigation is essential (*see* page 273).

DIRECTION OF FORCE — A knowledge of the direction of the force is useful, not only in determining the type of fracture, but, more important, in assessing the likelihood of damage to soft tissues.

Indirect violence (twisting) causes a spiral fracture; soft-tissue damage is slight.

A direct crushing force breaks the bone at the site of impact, either transversely or, if the force is greater, with comminution; crush injuries are dangerous in that they also damage soft tissues extensively.

A direct tapping force (such as a kick) also breaks the bone at the site of impact, the line of fracture being transverse or slightly oblique; the skin may be cut but is not devitalized, nor are other soft tissues crushed.

A fall from a height may cause a comminuted fracture of cancellous bone; the soft tissues may be bruised.

AGE OF PATIENT — Many fractures occur in a limited age distribution. Thus, a fall on the outstretched hand may produce a fracture-separation of the lower radial epiphysis in the child, a fractured scaphoid in the adult or a Colles' fracture in the older patient.

SYMPTOMS

A fracture is usually followed by pain and loss of function. A pathological fracture may, in addition, have been preceded by pain or by symptoms of an underlying cause (such as a tumour).

GENERAL SIGNS

A broken bone is part of a patient. It is important to look for evidence of the following conditions: (*a*) shock or haemorrhage; (*b*) associated damage to brain, spinal cord or viscera; and (*c*) a predisposing cause (such as Paget's disease).

Corrective strapping is often recommended for children but rarely succeeds.

Operative correction should be deferred until the age of 14 years; it is then indicated if there is a painful corn on the hammer toe. The affected toe is shortened and straightened by excising the joint. To ensure arthrodesis, the excised joint is splinted with a piece of Kirschner wire, the end of which projects from the tip of the toe. After 3 weeks the wire is removed and a collodion splint applied for a further 3 weeks.

CURLY TOES

Several toes are affected. As a rule the metatarsophalangeal joints are hyper-extended and the toe joints flexed. The condition is often bilateral and may be associated with pes cavus deformity. As with many foot deformities there is often a positive family history.

Painful callosities may develop on the dorsum of the toes or under the metatarsal heads. If conservative treatment by padding and footwear fails, the toes may be straightened surgically.

OVERLAPPING FIFTH TOES

This is a common congenital anomaly. If symptoms warrant, an attempt may be made to straighten the toe by a V-Y-plasty. If this fails, it may be necessary to amputate the toe.

Suggestions for further reading

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LOCAL SIGNS

A possible fracture must be handled gently. To elicit crepitus or abnormal movement is often cruel, and x-ray diagnosis is more reliable. Nevertheless the familiar headings of clinical examination should always be considered, or damage to arteries and nerves may be overlooked.

LOOK — Swelling and deformity may be obvious, but the important point is whether the skin is intact; if the skin is broken, whether from within or without, the fracture is open (compound).

FEEL — There is localized tenderness, but it is necessary also to examine distal to the fracture for the pulse and for loss of sensation.

MOVE — Crepitus and abnormal movement may be present, but it is more important to ask if the patient can move the limb distal to the injury.

X-RAY — X-ray examination is necessary to enable a fracture to be accurately described and is essential for medicolegal purposes. Certain pitfalls must be avoided, thus it may be necessary to take two views on two occasions, to examine two joints, or both limbs.

Two views — A fracture may not be seen on a single x-ray film, and at least two views (antero-posterior and lateral) must be taken. For the carpal scaphoid a third (oblique) view is necessary.

Two occasions — Soon after injury, a fracture (such as a fracture of the carpal scaphoid) may be difficult to see. If doubt exists, further examinations must be carried out 10 days later, by which time bone absorption at the fracture site makes diagnosis easier.

Two joints — In the forearm or leg one bone may be fractured and angulated. Angulation, however, is impossible unless the other bone is also broken, or a joint dislocated. The joints above and below the fracture must both be included on the x-ray films

Two limbs — In x-ray of a child's elbow, normal epiphyses may confuse the diagnosis of a fracture, and films of the uninjured elbow are then helpful.

DESCRIPTION

To diagnose the presence of a fracture is not enough; accurate description is an essential preliminary to treatment. It is helpful to consider description under three headings: (*a*) situation; (*b*) the line of fracture; whether transverse, oblique or comminuted; and (*c*) the direction of any displacement.

SITUATION — Which bone is broken? Whereabouts in the bone is the fracture? Has the fracture involved a joint surface?

LINE OF FRACTURE —

Transverse — A transverse fracture is slow to join because the area of contact is small; if the broken surfaces are accurately opposed, however, the fracture is stable to compression. Thus, with an accurately reduced transverse fracture of the tibia, weight bearing is safe (providing angulation is prevented by plaster).

Oblique (spiral) — A spiral fracture joins more rapidly because the area of contact is large; it is not, however, stable to compression. Thus, with a spiral fracture of the tibia, weight bearing is not safe (even in a well-fitting plaster), for the lower fragment is liable to displace upwards, producing overlap.

Comminuted — A comminuted fracture often joins very quickly, because the total surface area of the fragments is very large. Often, however, comminuted fractures are due to the crushing of cancellous bone, and compression is likely to redisplace the fragments unless reduction is followed by prolonged splintage. Thus, in crush fractures of the os calcis or of a vertebral body, redisplacement is so probable that reduction is often not worthwhile.

DISPLACEMENT — Displacement may conveniently be resolved into three components: (*a*) shift; (*b*) tilt; and (*c*) twist.
Shift — Sideways, backwards or forwards shift may occur.
Tilt — Tilt may also be sideways, backwards or forwards.
Twist — Twist may occur in any direction; there may also be impaction or overlap.

EXAMPLES OF PARTICULAR FRACTURES —
Typical supracondylar fracture in a child — The humerus is fractured just above the elbow and the fracture does not involve the joint; the fracture line is slightly oblique, being lower in front; the lower fragment is shifted backwards and laterally and is twisted inwards; there is overlap.
Typical Colles' fracture — The radius is fractured near its distal end and the wrist joint is not involved, the fracture line is transverse; the distal fragment is shifted backwards and radially, tilted backwards and radially, and twisted into supination; there is impaction

TREATMENT OF CLOSED FRACTURES

In outline, the treatment of a fracture is as follows.

GENERAL — The order of general treatment is as follows: (1) first aid; (2) transport; (3) treatment of shock, haemorrhage or associated injuries.

LOCAL — The order of local treatment is as follows: (1) reduce the fracture (by closed manipulation or open operation); (2) hold the fracture reduced (by continuous traction, plaster, or internal fixation); (3) treat the soft tissues (by elevation, exercises, or with the aid of internal fixation of the bone).

REDUCE

A fracture obviously needs reduction only if there is displacement; it is sometimes forgotten, however, that to reduce a displacement which will inevitably recur is a futile procedure.

CLOSED REDUCTION

Accurate reduction by closed manipulation is not a matter of chance; a methodical approach is necessary.

PRELIMINARY X-RAY — Careful study of the x-ray films is essential; often the direction of the force causing the fracture can be deduced.

ANAESTHESIA — A general anaesthetic is preferred if circumstances permit its use. Relaxants are often a great help.

TECHNIQUE — Traction along the line of the bone is usually the first manœuvre and is sometimes sufficient to achieve reduction. (With impacted fractures it may first be necessary to increase the angulation deformity in order to disimpact.) A force, the reverse of that which caused the fracture, is then applied (for example, for an external rotation Pott's fracture the foot is twisted inwards).

X-RAY CONFIRMATION — Reduction must be confirmed by x-ray (two views).

OPEN REDUCTION

Operative reduction is indicated only if closed reduction is impossible, insufficiently accurate, or futile.

CLOSED REDUCTION IMPOSSIBLE — Closed reduction may fail because (*a*) a small fragment is unmanageable (for example, the lateral condyle of the humerus); (*b*) a fragment is trapped in a joint (for example, the medial epicondyle of the humerus); or (*c*) soft parts are interposed (for example, a flap of periosteum in medial malleolar fractures).

CLOSED REDUCTION INACCURATE — With any fracture accuracy of reduction is desirable; in some it is imperative because (*a*) fractures which involve a joint surface, unless perfectly reduced, are likely to be followed by joint degeneration; and (*b*) fractures of the radius and ulna in adults, unless perfectly reduced, result in limited rotation.

CLOSED REDUCTION FUTILE — In some fractures (for example, of the olecranon process), internal fixation is the only satisfactory way to hold the fracture; therefore, although closed reduction is often easy, it is obviously futile.

HOLD REDUCTION

It is important first to consider the necessity for immobilizing a fracture. The accepted *view is that immobilization is essential; it must be rigidly enforced* and uninterruptedly prolonged until union is complete. Examples widely quoted to support this view are fractures of the carpal scaphoid bone, femoral neck and lower radius or tibia, which indeed often fail to unite unless immobilized rigidly and uninterruptedly. Consequently, the belief has arisen that "*immobilization* causes union", and that "every fracture needs plaster" These assumptions are unjustified; most fractures elsewhere unite whether splinted or not; if unsplinted, however, they may unite in poor position In fact, splintage is usually employed to prevent malunion (that is, to hold reduction) and less often to prevent non-union.

CONTINUOUS TRACTION

As a method of holding reduction, continuous traction is especially useful in spiral fractures of long bones. Traction reduces overlap, and the ensheathing effect of the surrounding muscles tends to correct shift and tilt In transverse fractures traction is liable to be excessive, to pull the ends apart and to leave them "floating". The great danger of continuous traction is overtraction, resulting in delay or non-union. To minimize this danger, whenever traction is employed, the longitudinal muscles crossing the fracture must be exercised regularly and repeatedly.

TRACTION BY GRAVITY ALONE — Traction by gravity alone is used in upper limb injuries. Thus a spiral fracture of the humerus is adequately held by a simple wrist sling; the weight

of the arm provides continuous traction and union will occur. If the fracture is transverse, a U-shaped plaster slab bandaged onto the arm prevents the fragments from wobbling about too much.

SKIN TRACTION — Skin traction is mainly used for hip and thigh injuries. Holland strapping, Zopla or one-way-stretch Elastoplast is stuck to the shaved skin and held on by a bandage. The malleoli are protected by Gamgee tissue, and cords or tapes are used for traction.

SKELETAL TRACTION — A Kirschner wire, Steinmann pin or Denham pin is inserted, usually through the upper tibia behind the tibial tubercle for hip and thigh injuries, occasionally lower in the tibia or through the os calcis for tibial fractures. Hooks which can swivel freely are attached, and cords tied to them for applying traction.

Mechanics — Traction must always be opposed by countertraction; that is, the pull must be exerted against something, or it merely drags the patient down the bed.

Fixed traction — The pull is exerted against a fixed point; for example, the tapes are tied to the crosspiece of a Thomas splint and pull the leg down until the ischial tuberosity abuts against the ring of the splint.

Balanced traction — The pull is exerted against an opposing force provided by the weight of the body when the foot of the bed is raised. The cords may be tied to the foot of the bed, or run over pulleys and have weights attached.

Combined traction — A Thomas splint is used, with the end of the splint tied to the foot of the bed, which is raised.

PLASTER

For a plaster splint to be efficient and comfortable, its application requires considerable skill.

TECHNIQUE — After a fracture has been reduced, stockinette is threaded over the limb and the bony points are protected with wool. Plaster is then applied and carefully moulded over the bony points; while the plaster is setting, the surgeon himself should hold the limb. If the fracture is a recent one and further swelling is likely, the plaster and stockinette are split from top to bottom, exposing the skin.

Check x-rays are essential and further x-rays must be taken after any change of plaster.

When the fracture is near a joint (for example, Colles' and Pott's fractures) only that joint is usually included With fractures of the shafts of long bones, the plaster must, as a rule, include the joint above and the joint below the fracture In the lower limb, the knee is usually held at an angle of 170 degrees, the ankle at an angle of 90 degrees and the tarsus and forefoot neutral (this is known as the plantigrade position and is essential for normal walking). In the upper limb the position of the splinted joints varies with the fracture.

INTERNAL FIXATION

Internal metal fixation may be of two varieties: (*a*) inlay; for example, by a trifin nail, intramedullary nail, or screws; or (*b*) onlay, which is always by a plate. Plates should be big and strong and must be screwed to the opposite cortex (*see also* page 109)

INDICATIONS — Operative fixation of a fracture is used to hold reduction when closed methods are impossible, inadequate, or futile.

Closed methods impossible — A transverse fracture of the olecranon process, for example, is easy to reduce by closed methods but can rarely be held reduced without internal fixation.

Closed methods inadequate — A fractured neck of femur (cervical fracture), for example, cannot be adequately held in plaster. Oblique fractures of the tibia and fibula are also difficult to hold in plaster and can only be held reduced providing the patient does not take weight.

Closed methods futile — If closed reduction of a medial malleolus has failed, and open reduction has been necessary, it is reasonable to proceed immediately to screw fixation, thereby ensuring that the fracture cannot subsequently slip. The additional risk of implanting metal is very slight. Similarly, if closed reduction of a radius and ulna has failed and open reduction has been necessary, the bones should (in the adult) be plated. It is important to note, however, that open reduction does not necessarily entail internal fixation for, even when open reduction is necessary in a child, internal fixation is rarely indicated.

DELAYED SPLINTAGE — Internal fixation alone is in many cases quite inadequate to hold reduction; it must often be supplemented by external splintage. If, for example, a patient walks with a recently plated tibia unprotected by plaster, the plate will break. The disadvantage of plating combined with plaster is that subsequent joint stiffness is often considerable.

To avoid such stiffness, delayed splintage is used: while the patient is in bed after plating, an incomplete plaster is worn. This is removed twice daily by the physiotherapist, who holds the leg while the patient moves the joints. By the time the stitches are removed, the patient has full range at all joints and is then given a complete plaster. When this is removed, there is little or no stiffness.

TIME FACTOR

Repair of a fracture is a continuous process, and any stages into which the process is divided are necessarily arbitrary. In this book the terms "union" and "consolidation" are used, and they are defined as follows:

Union — Union is incomplete repair; the ensheathing callus is calcified. Clinically the fracture site is still a little tender and, though the bone moves in one piece (and in that sense is united), *attempted angulation is painful* X-rays *show the fracture line still* clearly visible, with fluffy callus around it Repair is incomplete and it is not safe to subject the bone to unprotected stress.

Consolidation — Consolidation is complete repair; the calcified callus is ossified Clinically the fracture site is not tender, no movement can be obtained and attempted angulation is painless. X-rays show the fracture line to be almost obliterated and crossed by bone trabeculae, with well-defined callus around it Repair is complete and further protection is unnecessary

TIME-TABLE — How long does a fracture take to unite and to consolidate? No precise answer is possible because age, constitution, blood supply, type of fracture and other factors all influence the time taken. The only safe answer is that every fracture must be held reduced and protected from stress until consolidated.

Nevertheless, it is possible to forecast how long any particular fracture is likely to take and, providing it is not exclusively relied upon, such a forecast is useful. To estimate the time, *Perkins' time-table is useful.*

A spiral fracture in the upper limb takes 3 weeks to unite.

For transverse fractures, multiply by two.

For the lower limb, multiply by two.

For consolidation, multiply by two.

Thus a transverse fracture of the lower limb can be expected to take 24 weeks ($3 \times 2 \times 2 \times 2$) to consolidate, and will need to be protected from stress for the whole of that time. Even then there must be clinical and radiological evidence of consolidation before splintage is discarded. In children these times may often be halved.

TREATMENT OF SOFT TISSUES

A fracture is accompanied by soft-tissue damage which may involve muscles, capsule, ligaments, nerves or vessels. In particular, there is disturbance of the circulatory control in the limb, with extracellular oedema; unless this is properly treated, oedema fluid will gel and lead to adhesions.

Whereas a fractured bone may need to be kept still, soft-tissue damage and oedema are usually best treated by active movement. Here is a dilemma, and different surgeons resolve it by emphasizing one or other aspect of treatment. The fracture itself is of primary importance but the soft tissues must never be neglected. All too often an x-ray appearance is "treated" instead of the patient.

The objects of soft-tissue treatment are to pump away oedema fluid, to regain *circulatory control, to avoid soft tissues sticking together, to prevent muscle wasting* and (by exercising the longitudinal muscles crossing a fracture) to cause the bone ends to impinge more closely. The essence of soft-tissue treatment may be summed up thus: *elevate and exercise; never dangle, never force.*

ELEVATION

An injured limb usually needs to be elevated; this is particularly true of the lower limb. After reduction of a fracture, the foot of the bed is raised and exercises begun. If the leg is in plaster the patient is not allowed up until swelling subsides. Then the limb must, at first, be dependent for only short periods; between these periods, the leg is elevated on a chair. The patient is allowed, and encouraged, to exercise the limb actively, but not to let it dangle.

When plaster is finally removed, the leg is firmly bandaged and a similar routine *of activity punctuated by elevation is* practised *until* circulatory control has been fully regained.

Severe injuries of the upper limb also need elevation at first. With less severe injuries a sling is sufficient, providing the fingers are actively exercised.

EXERCISES

Passive exercises or forced movements are never, under any circumstances, permitted in the treatment of fractures. Active exercises, on the contrary, are encouraged and insisted upon.

All unsplinted joints must be used actively from the very start. A patient with a Colles' fracture, for example, must use the fingers, elbow and shoulder as normally as possible.

Joints encased in plaster cannot, of course, be moved, but the muscles passing over them can and must be exercised. A patient with a fractured leg, for example, is fitted with a special boot over the plaster; this boot has a rockered sole to compensate for lack of ankle movement. The patient is then taught to walk, using the normal heel-toe gait so that the long toe muscles are actively exercised. Even if weight bearing is unsafe and crutches must be used, the patient should still go through the motions of correct walking ("shadow walking").

OPERATIVE TREATMENT

Internal fixation of a fracture is sometimes required solely to treat the soft parts. This is indicated when closed methods are impossible, too difficult or time too precious.

CLOSED METHODS IMPOSSIBLE — In a fractured spine with paraplegia, for example, the spine is plated so that the patient can be easily nursed, or he is likely to develop bed sores.

CLOSED METHODS TOO DIFFICULT — Elderly patients with lower-limb fractures are often best treated operatively to permit early activity without the encumbrance of plaster; for example, a hip spica or prolonged traction may prove too much for a fat 80-year-old patient with a trochanteric fracture.

TIME TOO PRECIOUS — It is often justifiable to treat a pathological fracture through a secondary deposit by internal fixation because the patient may not have long to live and should enjoy activity for as long as possible.

APHORISMS OF FRACTURE TREATMENT

Treat the patient — Do not merely treat the fracture.
Think before you reduce — Is reduction necessary? Can it be held?
Think before you splint — Splintage is harmful, though often a necessary evil. Can the muscles or traction hold reduction without a splint? Are too many joints being splinted? Are the muscles being actively used? Is an unreduced fracture into a joint being splinted? If so, the surgeon is adding insult to injury.
Think before you discard a splint — Is the fracture sufficiently consolidated?
Never allow passive movement.

SUMMARY OF INDICATIONS FOR OPERATIVE TREATMENT OF FRACTURES

A compound fracture always requires urgent operation, namely wound excision —not internal fixation. In closed fractures the indications for operative treatment are as follows.

REDUCTION — Operation is necessary to reduce the fracture (open reduction) if (*a*) closed reduction is impossible; (*b*) closed reduction is insufficiently accurate; or (*c*) closed reduction is futile (because internal fixation is required).

HOLD REDUCTION — Operation is necessary to hold reduction (internal fixation) if

(*a*) closed methods of holding it are impossible; (*b*) closed methods of holding it are inadequate; or (*c*) closed methods of holding it are futile (because openly reduced).

TREATMENT OF SOFT TISSUES — Operation is necessary to treat the soft tissues if (*a*) closed methods make it impossible to treat the soft tissues; (*b*) closed methods make it too difficult to treat the soft tissues; or (*c*) time is too precious.

Most of these indications are, however, only relative. There is always a danger of introducing infection by operation, and this is a surgical disaster. Operative methods should therefore be avoided unless the aseptic technique of the surgeon, his team and his theatre are all above reproach.

TREATMENT OF COMPLICATIONS — The operative treatment of complications is discussed later.

TREATMENT OF OPEN FRACTURES

An open or compound fracture is one in which there is skin damage, so that bacteria from without may infect the fracture haematoma. The skin may be cut, or crushed (potential skin loss), or there may be actual skin loss. No matter which, and no matter whether the fracture is compound from within or without, it is a surgical emergency.

Treatment begins at the scene of the accident, where the prime objects are to save life and minimize shock. Apart from these objects, treatment is based on the following considerations: (*a*) bacteria may enter the wound (therefore prophylaxis); (*b*) bacteria may multiply in the wound (therefore wound excision); and (*c*) further bacteria may enter the wound (therefore wound closure).

PREOPERATIVE

At the scene of the accident, the essentials are a sterile pressure-dressing, splintage and morphia. A simple splint can usually be improvised; if not, an injured arm is bandaged to the trunk, and an injured leg to the uninjured one. The patient is transported to hospital as promptly as possible.

In hospital, antishock treatment is continued, and the patient is given antibiotics, antitetanus serum and anti-gas-gangrene serum.

WOUND EXCISION

The object of excision is to ensure a good blood supply to all parts of the wound, not to "sterilize" it, which is impossible. Under general anaesthesia the patient's clothing is removed, while an assistant maintains traction on the limb and holds it still. A sterile pad is placed over the wound and the surrounding skin is cleaned and shaved. The wound itself is then gently cleaned with a harmless detergent. A tourniquet is not permitted; its use would endanger the circulation still further and make it difficult to recognize which structures are devitalized. The tissues are then dealt with as follows.

SKIN — Only the merest sliver of skin is excised from the wound edges; as much skin as possible is spared. The wound often needs to be extended by planned incisions to obtain adequate exposure; once it is enlarged, clothing and other foreign material may be picked out.

FASCIA — Fascia is divided extensively.

MUSCLE — Dead muscle is dangerous, for it provides food for bacteria. Therefore all dead and doubtfully viable muscle is ruthlessly excised.

BLOOD VESSELS — Large bleeding vessels are tied meticulously but, to minimize the amount of catgut left in the wound, small vessels are clamped with artery forceps and twisted.

NERVES — It is usually best to leave a cut nerve undisturbed. If, however, the wound is clean and the nerve ends present without dissection, the sheath is sutured with one or two fine catgut stitches.

TENDONS — As a rule, cut tendons are also left alone. As with nerves, suture is permissible only if the wound is clean and dissection unnecessary.

BONE — The fractured surfaces are gently cleaned and replaced in correct position. Bone, like skin, should be spared, and fragments are removed only if they are small and totally detached. Immediate screwing or plating of open fractures has been advocated but is a dangerous practice.

WOUND CLOSURE

Immediate closure is the ideal, but is dangerous because, as tension rises within the wound, tissues may become avascular, providing food for bacteria, especially anaerobes.

If the wound overlies soft tissues, it is best left open, though covered with a Vaseline gauze dressing, and closure postponed until the dangers of tension and infection have passed.

A wound lying directly over a bone or joint should, if possible, be closed at the primary operation, and tension avoided by relieving incisions elsewhere in the limb. These incisions can, if convenient, be covered with split-skin grafts, this being a safer procedure than applying skin grafts directly to the wound.

A well-padded plaster is applied, and finally both plaster and wool must be widely split so that skin is visible.

AFTERCARE

In the ward, the limb is elevated and its circulation carefully watched. Shock may still require treatment. Chemotherapy is continued; if the antibiotic used proves ineffective, the organism is cultured and the appropriate drug substituted.

If the wound has been left open it is inspected at 5–7 days. Delayed primary suture is then often safe, or, if there has been much skin loss, split-skin grafts are applied.

If toxaemia or septicaemia persist in spite of chemotherapy, the wound is drained (the only safe treatment if an infected fracture is not seen until 24 hours after injury).

When all reasonable danger of infection has been overcome, definitive treatment of the fracture is carried out.

SEQUELS TO OPEN FRACTURES

SKIN — If there has been skin loss or contracture, grafting may be necessary. When reparative or reconstructive surgery to deeper tissues is required, a full-thickness skin graft is highly desirable.

BONE — Infection may lead to sequestra and to sinuses. Small sequestra should be removed early, but large pieces of bone should not be excised.

Delayed union is inevitable after an infected fracture, but union will occur if infection is controlled and immobilization maintained for sufficient time.

JOINTS — When an infected fracture communicates with a joint, the principles of treatment are the same as with bone infection, namely drugs, drainage and splintage. The joint should be splinted in the optimum position for ankylosis, lest this occur.

With any compound fracture, even if not communicating with a joint, some stiffness is almost inevitable. It can be minimized by slowly increasing active exercises once it is certain that infection has been overcome.

GENERAL COMPLICATIONS OF FRACTURES

SHOCK AND HAEMORRHAGE

PRIMARY SHOCK (NEUROGENIC) — Neurogenic shock occurs with painful injuries, emotional disturbances or both. It is due to widespread dilatation of peripheral arterioles, so that the effective volume of circulating blood is diminished. The patient may lose consciousness; his blood pressure is low, but he is not cold and the pulse rate is slow. The treatment is warmth, rest, and the relief of pain. Primary shock is transient; if the patient does not recover quickly, or if circulatory failure returns after recovering, secondary shock must be diagnosed.

SECONDARY SHOCK (OLIGAEMIC) — Oligaemic shock is due to loss of plasma or blood; either may have escaped from the wound surface or into the tissues. The loss of about 2 pints induces moderate shock; loss of 3 pints causes severe shock and larger quantities, profound shock.

The patient is ill, apathetic and thirsty. Breathing is shallow and rapid, the lips and skin are pale and the extremities feel cold and clammy. The pulse is rapid and feeble, and the blood pressure low. Imbibed fluids may be vomited and later there is oliguria. When the fluid lost is mainly plasma, haemoconcentration develops with an increased red cell count, high haemoglobin level and a reduced alkali reserve.

Treatment is urgent. Morphine (best given intravenously) and oxygen are valuable, but applied heat is now known to be harmful. The essential measure is early and adequate transfusion to restore the volume of circulating fluid. With haemoconcentration plasma is best, and at least 2 pints should be run in rapidly. When blood has been lost plasma may be given as a stop-gap, followed by blood. Accurate blood grouping takes time, and group O rhesus-negative blood may be used in emergency until homologous, cross-matched blood is available. The early reduction and splintage of fractures helps to combat shock.

HAEMORRHAGE — Haemorrhage is obvious in open wounds, but even with closed injuries there is far more bleeding into the tissues than is commonly appreciated. Up to 2 pints may be lost with a single major limb fracture, up to 4 pints with two major fractures, and up to 6 pints with three major fractures. In trunk fractures with visceral damage, half the blood volume may be lost.

The signs are those of secondary shock, but without haemoconcentration. Treatment is as for secondary shock, with emphasis on stopping bleeding and replacing lost blood.

CRUSH SYNDROME

The crush syndrome may occur if a large bulk of muscle is crushed, as by fallen masonry or a tourniquet which has been left on too long. When compression is released, acid myohaematin, from muscle breakdown, is carried in the circulation to the kidney and blocks the tubules. *An alternative explanation is that renal artery spasm occurs and the anoxic tubule cells necrose.*

Profound shock occurs and associated arterial damage is common. The released limb is pulseless and later becomes red, swollen and blistered; sensation and muscle power may be lost. Renal secretion diminishes and a low-output uraemia with acidosis develops. After about a week if renal secretion returns the patient survives; most patients become increasingly drowsy and die within 14 days.

To avert disaster, a limb crushed severely and for several hours should be amputated. Thus, if a tourniquet has been left on for more than 6 hours the limb must be amputated. Amputation is carried out above the site of compression and before compression is released.

Once the compression force has been released, amputation is valueless. The limb must be kept cool and the patient's shock treated. If oliguria develops the urine should be alkalinized by the intravenous administration of sodium lactate solution, but unless this induces renal secretion in a few hours it is discontinued for fear of alkalaemia. Desperate measures include peritoneal dialysis or by-passing the renal circulation (artificial kidney) with a "detoxicating" mixture.

VENOUS THROMBOSIS

The cause of venous thrombosis is not established. In the calf veins it may be due to (*a*) pressure against the operating table or mattress, or a tight bandage, resulting in stasis and possibly intimal damage; (*b*) slowing of the blood flow because of immobility; or (*c*) a raised blood thrombin level, lowered antithrombin level and increased number and stickiness of platelets, all of which follow operation or injury.

Slight pyrexia develops 5–10 days after injury or operation; the calf is painful, swollen and tender, and passive dorsiflexion of the foot causes pain (Homan's sign). Every nurse and physiotherapist should be trained to watch for these signs.

Thrombosis of the upper thigh veins may be due to extension of calf vein thrombosis, or it may be primary, especially following an excessively flexed position of the hip. The upper thigh is painful and tender, and the limb becomes swollen with oedema (white leg).

PROPHYLAXIS — Prophylaxis is important Pressure can be avoided by the use of Sorbo pads, and stasis minimized by getting the patient up, or at least moving about in bed, as early as possible. With a history of thrombosis on previous occasions, anticoagulants are used prophylactically

ANTICOAGULANTS — Anticoagulants are often given as soon as venous thrombosis is diagnosed. The drugs used are heparin, which neutralises the action of thrombin, and phenindione (Dindevan), which inhibits prothrombin formation in the liver.

Dosage — A dosage scheme in current use is as follows. (1) Immediately: heparin (10,000 units) is injected intravenously and phenindione (100 mg) is given by mouth.

(2) Two hours after diagnosis: heparin (20,000 units) is injected into the deep subcutaneous tissues. (3) Twelve hours after diagnosis: heparin (20,000 units) is given by deep subcutaneous injection and phenindione (100 mg.) by mouth. (4) From 24 hours after diagnosis: phenindione (50 mg.) is given by mouth once or twice a day depending upon the prothrombin index; this is determined daily and should be maintained at 25–40 per cent of the normal. If the signs have disappeared, treatment is discontinued after 3 weeks.

VEIN LIGATION — Ligation of the vein is rarely practised, because emboli do not necessarily come from the obviously affected veins, or even from the clinically abnormal limb.

PULMONARY EMBOLISM

Pulmonary embolism is a complication of venous thrombosis, though in half the cases no preceding signs of thrombosis have been detected. In phlebothrombosis (as distinct from thrombophlebitis) the clot is not firmly adherent to the vein wall and emboli may break off and lodge in the lung.

A small embolus may cause few symptoms but is a warning that larger emboli may follow. Larger emboli cause pain, haemoptysis and dyspnoea; there is a pleural rub and evidence of lung consolidation. The occasional patient is seized with sudden chest pain, turns pale and falls dead.

PROPHYLAXIS — Prophylaxis is the same as for venous thrombosis. Anticoagulant therapy is used because of the danger of pulmonary embolism.

ANTICOAGULANTS — Anticoagulants are essential if a small embolus has occurred; and antibiotics should be given to prevent infection.

FAT EMBOLISM

Fat globules from an injured site may enter veins and be distributed widely by the circulation. This complication is least rare in fractures, perhaps because soft tissues cannot compress damaged veins within a bone.

Fat emboli may lodge in (*a*) lung, producing pulmonary oedema, dyspnoea and fat in the sputum; (*b*) small coronary vessels, producing a low blood pressure and a rapid feeble pulse; (*c*) skin, producing petechiae, especially over the front of the chest; (*d*) brain, producing headache, restlessness, drowsiness, vomiting and hyperthermia; or (*e*) kidney, producing fat in the urine.

Probably most cases pass unnoticed and many mild cases recover. In suspected cases, oxygen and antibiotics are advisable. No specific treatment is known, and some patients die. It has been said that fat embolism is the cause of death in 20 per cent of fatal fractures.

OTHER GENERAL COMPLICATIONS

"FRACTURE FEVER" — This is a doubtful entity, though it is true that the absorption of a haematoma often causes slight pyrexia. If fever persists for more than 72 hours it is, however, wise to presume the presence of infection.

DELIRIUM TREMENS — This may follow injury in a chronic alcoholic, and lead to alarming but characteristic symptoms.

LOCAL COMPLICATIONS OF FRACTURES

Injuries of the trunk may be complicated by damage to viscera or the spinal cord, and the treatment of this damage takes precedence over the treatment of the fracture (*see* Chapter 23). In the account which follows the complications associated with limb fractures are considered, taking each tissue in turn.

SKIN COMPLICATIONS

The most important local complication of a fracture is skin damage. The treatment of open fractures and of the tissues damaged in an open wound has already been described (*see* page 259).

FRACTURE BLISTERS — *These are due to elevation of the superficial layers of skin by* oedema. They can be prevented by firm bandaging. Once they have developed only a sterile dry dressing is necessary.

PLASTER SORES — Plaster sores occur where skin presses directly onto bone. They should be prevented by padding the bony points and by moulding the wet plaster so that pressure is distributed to the soft tissues around the bony points. While a plaster sore is developing the patient feels localized burning pain. A window must immediately be cut in the plaster, or warning pain quickly abates and skin necrosis proceeds unnoticed.

BED SORES — Bed sores occur in elderly or paralysed patients. The skin of the sacrum and heels is especially vulnerable. Careful nursing and early activity can usually prevent bed sores; once they have developed treatment is difficult, and it may be necessary to excise the necrotic tissue and apply skin grafts.

MUSCLE COMPLICATIONS

TORN MUSCLE FIBRES — Torn muscle fibres are common with any fracture. Unless the muscle is actively exercised the torn fibres may become adherent to untorn fibres, capsule or bone; if adhesions have been allowed to develop, lengthy rehabilitation will be necessary after the fracture has consolidated. The fracture and the torn muscles both *need treatment: it is better to serve two sentences concurrently than consecutively.*

DISUSE ATROPHY — Like adhesions, disuse atrophy is largely the result of neglect in treatment, and is usually preventable by repeated active muscle exercises.

TENDON COMPLICATIONS

TORN TENDON — A torn tendon is rare in association with a closed fracture, except in transverse fractures of the patella or olecranon process; in these fractures, the loss of continuity of the extensor mechanism of the joint is more important than the fracture.

AVULSION FRACTURES — Avulsion fractures in which the tendon remains intact but pulls off a small flake of bone, occur at the shoulder (supraspinatus tendon), the fingers (mallet finger), the knee (patellar tendon) and the lesser trochanter (psoas tendon).

LATE RUPTURE — Late rupture of the extensor pollicis longus muscle may occur 6–12 weeks after a fracture of the lower radius This tendon may also rupture "spontaneously" (*see* page 142).

TENDINITIS — Tendinitis may affect the tibialis posticus tendon following medial malleolar fractures It should be prevented by accurate reduction, if necessary at open operation

NERVE COMPLICATIONS

NERVE INJURY — Nerve injury (*see* Chapter 10) is not uncommon in association with a fracture. Usually the lesion is a neurapraxia which quickly recovers. Axonotmesis is liable to occur when the injury (fracture or dislocation) imposes severe traction on the nerve. Neurotmesis is rare with closed fractures.

Nerve damage should be diagnosed during the initial examination of the patient. In closed fractures recovery is usual and should be awaited. If recovery has not occurred by the expected time, the nerve should be explored as soon as the fracture has consolidated.

COMPRESSION — Nerve compression may damage the lateral popliteal nerve if an elderly or emaciated patient lies with the leg in full external rotation. Radial palsy may follow the faulty use of crutches. Both conditions are due to bad treatment.

LATE ULNAR NEURITIS — This condition results from a valgus elbow following a mal-united supracondylar fracture or an un-united lateral condyle (*see* page 97).

COMPLICATIONS INVOLVING THE ARTERY TO THE LIMB

GANGRENE

Gangrene occurs only if the limb or part of it is completely deprived of arterial blood for several hours. The arteries may have been divided, thrombosed or in spasm, or constricted by oedema, especially if an encasing plaster prevents the limb from swelling. The popliteal artery is especially vulnerable in dislocations of the knee. If the circulation to a limb is impaired, prompt reduction of a fracture or dislocation is imperative and is sometimes followed by return of pulsation.

VOLKMANN'S ISCHAEMIA OF THE FOREARM

PATHOLOGY

ARTERIAL DAMAGE — The brachial artery or both the radial and ulnar arteries may be cut, contused, compressed, thrombosed, or occluded by spasm; spasm may spread to the collateral branches. The effects of the resulting ischaemia vary. Nerve tissue can survive only a short period of ischaemia, but can regenerate; muscle can survive 6–8 hours ischaemia, but cannot regenerate. Arterial obstruction must be incomplete or not too long-lasting if Volkmann's ischaemia is to occur.

SYMPTOMS

Following an injury or its treatment, the patient complains of forearm pain which is severe, and often agonizing

SIGNS

LOOK — The fingers may look pale, bluish or mottled.

FEEL — The radial pulse may be absent. Sensation in the fingers may be diminished. The forearm is tense and tender.

MOVE — Attempts to straighten the fingers are painful and resisted.

X-RAY — Immediate x-ray will determine whether displacement of the fracture has occurred.

PAIN — No single sign is to be relied upon for diagnosis, but severe pain, if associated with any one of the signs described, is the signal for urgent action.

TREATMENT

IMMEDIATE MEASURES — (1) The front half of any encircling splints or bandages, which might be causing compression, must at once be removed; the skin of the entire front of the limb should be visible. (2) The elbow, if acutely flexed, is straightened a little to ensure that the artery is not unduly kinked. (3) The elbow is x-rayed and, if the position of the bones suggests that the artery is being compressed or kinked, prompt reduction is necessary. (4) The limb is kept cool to reduce its metabolic requirements. (5) The theatre staff are warned to prepare for an emergency operation in an hour's time.

OPERATION — One hour after the immediate measures were taken the patient is re-examined. Unless the signs of ischaemia have abated immediate operation is necessary. *Technique* — The skin and fascia are divided over a considerable length, and the brachial artery exposed. If it has been divided, the artery should be ligated. Usually it is in spasm, in which case it should be bathed in a warm 2·5 per cent solution of papaverine sulphate. Pulsation may return; if not, no further useful action can be taken. The wound is not sutured, but is covered with Vaseline gauze and a light dressing. Delayed suture may be performed after a few days.

AFTERCARE — If ischaemia has not been averted, prolonged physiotherapy (wax baths, exercises and prolonged passive stretching on a "banjo" splint) may help to minimize contracture

VOLKMANN'S CONTRACTURE OF THE FOREARM

Volkmann's contracture is the sequel to ischaemia of the forearm muscles. They become fibrosed and subsequently contract. Nerves damaged by ischaemia may recover. Long after an injury associated with severe pain, the patient may present with deformity, stiffness, weakness and possibly numbness of the hand.

SIGNS

LOOK — The forearm is thin and the hand clawed, all the fingers are hyperextended at the metacarpophalangeal joints and flexed at the proximal and distal interphalangeal joints.

FEEL — Sensation in the fingers may or may not have recovered.

MOVE — Because the contracture is due to shortening of the flexor muscles the patient can extend his fingers only when he flexes the wrist. Gripping with the fingers can be accomplished by extending the wrist, but the function of the hand is poor.

X-RAY — This may show evidence of the old injury.

TREATMENT

MUSCLE SLIDE — The origin of the flexor muscles may be moved distally. Though this reduces the deformity it does not increase the total excursion of the muscle fibres, and there may be no improvement in function.

EXCISION AND TRANSPLANTATION — Seddon has shown that in suitable cases remarkable improvement in function can be obtained. Necrotic muscles are excised and contracted tendons divided. The wrist dorsiflexors or other available functioning tendons are transplanted to the cut distal ends of the finger flexors. If necessary, the median nerve is grafted.

ISCHAEMIA AT OTHER SITES

Ischaemia of the hand may follow forearm injuries, or swelling of the fingers associated with a tight forearm bandage or plaster. The intrinsic hand muscles fibrose and shorten, pulling the fingers into flexion at the metacarpophalangeal joints, but the interphalangeal joints remain straight. The thumb is adducted across the palm (Bunnell's "intrinsic-plus" position).

Ischaemia of the calf muscles may follow injuries or operations involving the popliteal artery or its divisions. It is not as rare as is usually supposed. The symptoms, signs and subsequent contracture are similar to those following ischaemia of the forearm. Occasionally, ischaemia may affect the intrinsic muscles of the foot.

Wherever ischaemia occurs the principles of treatment are those outlined above.

COMPLICATIONS INVOLVING THE ARTERY TO THE BONE

AVASCULAR NECROSIS

Bone dies when deprived of its blood supply.

SITES

FEMORAL HEAD — Avascular necrosis of the femoral head may follow cervical fracture or traumatic dislocation. Segmental necrosis may follow nailing a cervical fracture.

CARPAL BONES — The proximal portion of the carpal scaphoid and the semilunar may become avascular following carpal fracture or dislocation (*see* pages 302–304).

OTHER SITES — Part of the talus may become avascular following a fracture, or the whole bone may become so after dislocation. The head of the humerus rarely becomes avascular. Following fractures into joints, small fragments of bone not infrequently become avascular.

Avascular necrosis is not exclusively a complication of fractures and dislocations. Thus, the femoral head may become avascular after forcible reduction of a congenital hip dislocation or a slipped epiphysis, and "spontaneously" in pseudocoxalgia. Other important sites of avascular necrosis are described in the section on osteochondritis (*see* Chapter 5).

EFFECTS

At first there are no radiological changes. These do not appear for at least 6 weeks, often not for 3–6 months, and sometimes not for years. The dead bone then appears dense on x-ray. This density is largely relative because the avascular bone cannot share in the rarefaction of the surrounding bones which follows immobilization.

DELAYED UNION — This is inevitable in the presence of avascular necrosis, but union may occur if the bones can be held still until revascularization has taken place.

NON-UNION — Non-union is likely if the fracture has not been adequately immobilized (for example, as may occur with a fracture of a carpal scaphoid), or if it cannot be adequately immobilized (for example, neck of femur).

OSTEOARTHRITIS — Osteoarthritis is always liable to follow avascular necrosis, especially if dead bone is allowed to crush with stress.

BONE COMPLICATIONS

DELAYED UNION

The time-table on page 257 is no more than a rough guide to the length of time in which a fracture may be expected to unite and consolidate. It must never be relied upon in deciding when treatment may be discontinued. If, however, the time is unduly prolonged, the term "delayed union" is used.

CAUSES

INADEQUATE BLOOD SUPPLY — The bones which are liable to avascular necrosis (*see* page 267) are liable to delayed union. The lower third of the tibia is also vulnerable.

INFECTION — An open fracture is slow to join, probably because there is little fracture haematoma in which ensheathing callus can form; infection delays union still further.

"INADEQUATE PATIENT" — The bones of old people are slow to join and this is possibly true also of weak and debilitated patients.

INADEQUATE IMMOBILIZATION — This may take the form of (*a*) insufficient splintage; for example, a below-knee plaster does not hold a fractured shaft of tibia adequately; or (*b*) excessive traction, which pulls the bones apart. Splintage for too short a time is not, strictly speaking, a cause of delay; if splintage is discontinued before consolidation is complete, non-union may develop.

INTACT FELLOW BONE — If one bone in the forearm or leg is unbroken, the fractured ends of the other may be held apart, and some delay is then inevitable.

SIGNS

LOOK — There may be no abnormality.
FEEL — The fracture site is tender.
MOVE — The bone may appear to move in one piece; if, however, it is subjected to stress, pain is immediately felt and the bone may angulate, the fracture is not consolidated.
X-RAY — The fracture site is still clearly visible, and there may be some bone absorption. The bone ends are not sclerosed

TREATMENT

CONSERVATIVE — Delayed union is the signal to continue efficient treatment of the fracture, and to continue it uninterruptedly until consolidation is complete. If plaster is being used, it must be sufficiently extensive and must fit accurately. If traction is being used it must not be excessive; it is sometimes better replaced by plaster splintage.

OPERATIVE — Occasionally, where a fractured tibia is being held apart by a fibula which was not fractured or which has united quickly, it is worthwhile excising 1 inch of fibula and reapplying plaster.

NON-UNION

The term "non-union" implies that bony union cannot occur without operation. Usually the fragments are joined by fibrous tissue.

CAUSES

INADEQUATE IMMOBILIZATION — Unless delayed union is recognized, and the fracture adequately treated, non-union is liable to result. Some fractures (for example, those of the carpal scaphoid, lower radius, and lower tibia) are especially prone to non-union unless splintage is adequate. With these fractures the term "adequate" means that splintage is sufficiently extensive to prevent movement and uninterruptedly prolonged until consolidation is complete.

TOO LARGE A GAP — If the fracture surfaces are too widely separated union takes a very long time or may never occur. The gap may be due to a gunshot fracture which destroys a large section of bone, to muscle retraction, in which the patient's own muscles pull the fragments apart (as in a fractured patella), or to treatment with excessive traction.

INTERPOSITION — Non-union is liable to develop when any one of the following tissues is interposed between the bone ends: periosteum (for example, a flap of periosteum in association with a fractured medial malleolus); muscle (for example, a fractured femur may spike through the quadriceps muscle, which is consequently interposed between the bone ends); cartilage (for example, a fractured lateral condyle of humerus may be so rotated that its cartilaginous articular surface faces the shaft, and unless the condyle is replaced non-union is inevitable).

SIGNS

LOOK — There may be no abnormality, or there may be deformity.
FEEL — A gap may be palpable. The fracture is not tender.
MOVE — The bone does not move in one piece. Moving the fracture through a few degrees is painless; this painless movement is diagnostic.
X-RAY — The fracture is not united, and often the fracture surfaces are sclerosed.

TREATMENT

Non-union can nearly always be avoided by efficient treatment; occasionally interposed tissue must be removed. The treatment of established non-union is as follows.

CONSERVATIVE — An external splint may permit useful function. It may be all that is necessary or, indeed, all that is possible.

OPERATIVE — Splintage, no matter how extensive and prolonged, can never lead to union once non-union is established (that is, a painless hinge of movement and sclerosis of the bone ends visible on x-ray). To obtain union operation is necessary.

Technique — The fracture is exposed, and the surfaces rawed by excising sclerosed bone. Usually a cortical bone graft is fitted across the fracture and sometimes fixed with screws; the gap is packed with cancellous chip grafts. The limb is encased in a split plaster which is replaced by an unsplit plaster when the wound has healed.

MAL-UNION

CAUSES

PRIMARY — The fracture was not reduced.

SECONDARY — The fracture was not held reduced (redisplacement).

GROWTH DISTURBANCE — Damage to the growth disc is often postulated, but disturbance of growth is surprisingly rare even with fracture-separation of epiphyses. The epiphysis and growth disc are displaced together; the line of fracture is immediately next to the growth disc on its metaphyseal side, and the growth disc is consequently undamaged.

SIGNS

The deformity is usually obvious. There may be painful limitation of joint movement (for example, osteoarthritis of the ankle years after a mal-united Pott's fracture). At the elbow valgus deformity may present with delayed ulnar palsy.

TREATMENT

After reduction of a fracture, displacement is liable to recur during the first week, even in plaster, and with many fractures a check x-ray at one week is necessary.

The treatment of established mal-union may be conservative or operative.

CONSERVATIVE — If shortening is the main feature a raised shoe is usually sufficient treatment. Often no treatment is required, because a bone may grow straight, or because a neighbouring ball-and-socket joint can compensate for the deformity.

OPERATIVE — Osteotomy may be necessary if deformity is unsightly or to prevent the development of osteoarthritis.

JOINT COMPLICATIONS

A fracture or a joint injury may be accompanied by haemarthrosis, which is best aspirated. An open fracture may communicate with a joint (*see* page 261), and a penetrating wound may infect a joint.

As the sequel to a fracture a joint may be unstable or too stiff.

INSTABILITY

With a gunshot fracture, there may be extensive bone loss and consequent flailness. Usually the only treatment possible is an external splint.

A joint may be unstable in the sense that recurrent dislocation occurs following an injury, particularly at the shoulder or ankle. Recurrent dislocation may be preventable by splintage, but can only be cured by operation.

STIFFNESS

Limited movement at a joint, one of the commonest complications of a fracture, has a variety of causes.

INFECTION — Infection of a compound fracture nearly always causes considerable stiffness of long duration.

ADHESIONS — Adhesions of muscle to capsule or bone are likely to follow prolonged splintage, persistent oedema or inadequate treatment of the soft tissues. Adhesions can be minimized by muscle exercises. If stiffness persists, the joint is manipulated under anaesthesia when the fracture has consolidated.

MAL-UNION — Mal-union may restrict movement; for example, mal-union of the radius and ulna limits forearm rotation; cross-union, which is rare, prevents all rotation.

MYOSITIS OSSIFICANS — This is a post-traumatic condition in which calcium is deposited outside the bone, and joint movement is restricted. Nowadays it is usually called "traumatic subperiosteal ossification", a term which implies that the cause and pathology are fully understood. It is assumed that movement spreads bone cells further afield within the subperiosteal haematoma. This is unlikely to be the complete explanation, for myositis ossificans rarely follows operations on bone. However, movement, even if not the sole cause of myositis ossificans, certainly increases its severity. Passive movement in particular is dangerous, and passive movements must always be avoided in the treatment of any bone or joint injury.

The commonest site is the elbow. A few weeks after injury, movement, instead of increasing, is found to be getting less. The elbow may be painful and almost totally stiff. X-rays show a fluffy mass of calcification in front of the elbow.

At the first hint that movement is decreasing or calcification developing, the elbow should be rested in a plaster gutter. Months later, the fluffy mass of callus appears smaller and more discrete; its removal then is sometimes followed by increased movement.

Myositis ossificans may occur without bony injury, as following a kick on the front of the thigh. A large haematoma of the thigh should if possible be aspirated. Injection of hyaluronidase minimizes the risk of myositis ossificans in such injuries.

SUDECK'S ATROPHY — Sudeck's atrophy occasionally affects the foot, but usually the hand, often after relatively trivial wrist or forearm injuries. Pain and stiffness of fingers come on a few weeks after injury. The fingers are puffy, patchily discoloured, unduly moist, hyperaesthetic and stiff. X-rays show patchy rarefaction of the bones.

With prolonged physiotherapy (heat, elevation and graduated exercises) recovery is slow but steady over many months. Intra-arterial injection of Novocain, or stellate ganglionectomy, has been claimed to accelerate recovery.

OSTEOARTHRITIS — Osteoarthritis is liable to follow mal-union when the joint surfaces remain incongruous, or when the direction of stress transmission is abnormal. Avascular necrosis is a potent factor, for the dead bone may crush, causing further incongruity. Occasionally arthrodesis may be required.

PATHOLOGICAL FRACTURES

A pathological fracture may be defined as one which follows an injury insufficient to break a normal bone. Fractures of normal bone sustained by a patient with tabes or epilepsy or during convulsive therapy are not truly pathological; they are caused by uncontrolled voilence or uncoordinated muscle action.

CAUSES

A great variety of disorders may weaken bone and predispose to pathological fracture. Most of the causal conditions are fully described in Chapter 6, to which reference should be made.

CONGENITAL WEAKNESS OF BONE

Brittle bones (osteogenesis imperfecta) is the least uncommon example. Rare congenital causes include dyschondroplasia, marble bones and arachnodactyly. An example of localized congenital bone weakness is congenital pseudarthrosis of the tibia.

ACQUIRED GENERALIZED WEAKNESS OF BONE

Under this heading are three groups of causes, all of which have been described in Chapter 6.

NUTRITIONAL AND METABOLIC DISORDERS — This group includes rickets, osteomalacia and scurvy.

ENDOCRINE DISOR[illegible] osteoporosis, and fractures during cortisone [illegible] epiphysis resembles a pathological fracture a [illegible], but the bone weakness is localized.

DISORDERS ASSOCIATED WITH THE ELDERLY — This group includes senile osteoporosis, Paget's disease and multiple malignant deposits.

ACQUIRED LOCALIZED WEAKNESS OF BONE

Under this heading are three groups of causes.

DISUSED OR MISUSED BONE —

Post-traumatic disuse atrophy — Post-traumatic disuse atrophy of bone occurs unless the muscles around a splinted fracture have been exercised; when plaster is removed the atrophic bone may fracture.

Poliomyelitis — Poliomyelitis with much paralysis leads to bone atrophy and the bones break easily.

Stress fractures — Stress fractures in bone resemble fatigue fractures in metal, and may follow repeated minor stress Much the commonest site is a metatarsal bone (march fracture; *see* page 356). Rare sites are the upper tibia, the upper or lower fibula and the shaft or neck of the femur.

DISEASED BONE —

Paget's disease — Paget's disease is a common cause of pathological fracture, especially in the upper femur.

Osteomyelitis — Osteomyelitis is an uncommon cause. In acute osteomyelitis, pain enforces rest, and fracture is consequently rare. In chronic pyogenic osteomyelitis the dense sclerosed bone is unlikely to break, but in syphilitic osteomyelitis fracture can occur.

"*Irradiation fracture*" — This is the term used for an apparently spontaneous fracture of the femoral neck after radiotherapy for a pelvic tumour.

BONE REPLACED BY OTHER TISSUE —

Cyst — A cyst within a bone weakens it and predisposes to fracture. A cyst may be solitary; multiple cysts occur in fibrous dysplasia and in hydatid disease. Cyst-like deposits also occur in the lipoid diseases and in eosinophilic granuloma.

Benign tumour — A benign tumour of bone, especially a chondroma (occasionally haemangioma or benign giant-cell tumour), may be the site of a fracture.

Malignant tumour — Malignant tumours, especially secondary deposits or multiple myelomata, are common causes of pathological fracture. Occasionally fracture occurs through an osteolytic type of osteogenic sarcoma.

INVESTIGATIONS

The underlying cause of a pathological fracture usually emerges during routine examination.

GENERAL SYMPTOMS

A history of many previous fractures may suggest a diagnosis of brittle bones.

An operation, no matter how long ago, may have been performed for the removal of a tumour; the present fracture may be the first evidence of metastasis.

Symptoms such as loss of weight, pain, a lump, cough, or haematuria, suggest that the fracture may be through a secondary deposit.

LOCAL SYMPTOMS

Three questions are important. Was the force insufficient to break normal bone? Was the fracture preceded by pain (for example, of a tumour, or Paget's disease)? Was the bone bent before it fractured (as in Paget's disease)?

GENERAL SIGNS

AGE — Under the age of 20 years, only three causes are common: chondroma (in the fingers or toes); cyst (in a finger or a long bone metaphysis); and march fracture (of a metatarsal bone).

Over the age of 40 years, only three causes are common: Paget's disease (especially of the upper femur), osteoporosis (in the spine or femoral neck); and secondary carcinoma (in the spine or "root" bones).

GENERAL APPEARANCE — The underlying cause may be suggested by cachexia (malignant disease) or by multiple gross deformities (brittle bones, generalized Paget's disease, or von Recklinghausen's disease).

GENERAL EXAMINATION — A thorough general examination is necessary and it is useful to proceed systematically, in the following manner

Head — There may be evidence of Paget's disease or rickets.

Neck — Cervical lymph nodes or the thyroid gland may be enlarged

Chest — Lumps may be palpable in a breast or axilla, and examination of the lung may suggest a tumour.

Abdomen — The abdominal viscera, kidneys and groins must be palpated.

Pelvis — Examination of the pelvis is incomplete without rectal and vaginal examination.

Central nervous system — There may be evidence of a brain, spinal cord or root tumour, or of neurosyphilis.

LOCAL SIGNS

SITE — The site of the fracture often suggests the cause.
Spine — Osteoporosis, secondary deposit and myelomatosis.
Femoral neck — Osteoporosis, secondary deposit and irradiation.
Femoral shaft — Paget's disease and secondary deposit.
Near end of a long bone — Solitary cyst, giant-cell tumour, and sarcoma.
Fingers — Chondroma and cyst.
Toes — March fracture and chondroma.

X-RAY OF BONE AS A WHOLE —
Shape — A bent bone suggests brittle bones, Paget's disease, or old rickets.
Density — Generalized decreased density is seen in rickets, disuse atrophy and osteoporosis.
Architecture — The bone architecture is abnormal in Paget's disease, haemangioma and fibrous dysplasia.

X-RAY OF FRACTURE — The appearance of the bone around the fracture may suggest the underlying cause.
Periosteum — The periosteum may show callus with a march fracture or sunray spicules and Codman's triangle with a sarcoma.
Cortex — The cortex may be thinned or eroded by a tumour, or thickened in Paget's disease.
Medulla — The medulla may contain a rarefied area with well-defined borders (solitary cyst, giant-cell tumour, chondroma), or a rarefied area with an ill-defined border (malignant tumour), or an area of altered architecture (fibrous dysplasia, Paget's disease).

NOTE ON VERTEBRAE — An ordinary crush fracture is nearly always of the upper border. With a fracture through malignant disease the anterior border may be eroded; with osteoporotic fractures the discs are ballooned.

ADDITIONAL INVESTIGATIONS

X-RAY EXAMINATION — X-ray of other bones, the lungs and the urogenital tract may be necessary to exclude malignant disease.

BLOOD INVESTIGATION — Investigations should always include a full blood count, a Wassermann reaction and, where necessary, electrophoresis, paper chromatography or chemical analysis.

URINE EXAMINATION — Urine examination may reveal blood from a tumour, or Bence Jones protein in myelomatosis.

TREATMENT

The underlying disease should if possible be treated.

Nearly all pathological fractures unite, and many at normal speed; most can be treated in the same way as fractures through normal bone.

Fracture through a benign tumour is best treated by curetting or excising the tumour; bone grafting is then often necessary.

Fracture through a sarcoma is often an indication for amputation.

Fractures through secondary deposits may unite with conservative treatment, but

ternal fixation is often preferred to enable the patient to enjoy activity during his maining months of life. Radiotherapy and control of the hormone environment drugs or operation are also of value.

Suggestions for further reading

Aird, I. (1957). *A Companion in Surgical Studies.* 2nd Ed. Edinburgh; Livingstone.
Bunnell, Sterling (1953). "Ischaemic Contracture, Local, in the Hand." *J. Bone Jt Surg.*, 35A, 88.
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[illegible] " *J. Bone Jt Surg.*, 24, [illegible]
— and Johnson, R. W. (1943). "The Healing of Fractures." *Ibid.*, 25, 375.
Watson-Jones, R. (1955). *Fractures and Joint Injuries.* 4th Ed. Edinburgh; Livingstone.

LOCAL SIGNS

SITE — The site of the fracture often suggests the cause.

Spine — Osteoporosis, secondary deposit and myelomatosis.

Femoral neck — Osteoporosis, secondary deposit and irradiation.

Femoral shaft — Paget's disease and secondary deposit.

Near end of a long bone — Solitary cyst, giant-cell tumour, and sarcoma.

Fingers — Chondroma and cyst.

Toes — March fracture and chondroma.

X-RAY OF BONE AS A WHOLE —

Shape — A bent bone suggests brittle bones, Paget's disease, or old rickets.

Density — Generalized decreased density is seen in rickets, disuse atrophy and osteoporosis.

Architecture — The bone architecture is abnormal in Paget's disease, haemangioma and fibrous dysplasia.

X-RAY OF FRACTURE — The appearance of the bone around the fracture may suggest the underlying cause.

Periosteum — The periosteum may show callus with a march fracture or sunray spicules and Codman's triangle with a sarcoma.

Cortex — The cortex may be thinned or eroded by a tumour, or thickened in Paget's disease.

Medulla — The medulla may contain a rarefied area with well-defined borders (solitary cyst, giant-cell tumour, chondroma), or a rarefied area with an ill-defined border (malignant tumour), or an area of altered architecture (fibrous dysplasia, Paget's disease).

NOTE ON VERTEBRAE — An ordinary crush fracture is nearly always of the upper border. With a fracture through malignant disease the anterior border may be eroded; with osteoporotic fractures the discs are ballooned.

ADDITIONAL INVESTIGATIONS

X-RAY EXAMINATION — X-ray of other bones, the lungs and the urogenital tract may be necessary to exclude malignant disease.

BLOOD INVESTIGATION — Investigations should always include a full blood count, a Wassermann reaction and, where necessary, electrophoresis, paper chromatography or chemical analysis.

URINE EXAMINATION — Urine examination may reveal blood from a tumour, or Bence Jones protein in myelomatosis.

TREATMENT

The underlying disease should if possible be treated.

Nearly all pathological fractures unite, and many at normal speed; most can be treated in the same way as fractures through normal bone.

Fracture through a benign tumour is best treated by curetting or excising the tumour; bone grafting is then often necessary.

Fracture through a sarcoma is often an indication for amputation.

Fractures through secondary deposits may unite with conservative treatment, but

COMPLICATIONS

DAMAGE TO VESSELS OR NERVES — This is very rare.
NON-UNION — Non-union occurs only if a surgeon is foolish enough to operate on the fracture.
MAL-UNION — Mal-union is invariable and leaves a lump; in a child the lump always disappears in time, and in an adult it usually does. A girl anxious to obtain a good cosmetic result quickly may be willing to undergo more drastic treatment: the fracture is manually reduced under anaesthesia and held reduced by a plaster cuirasse. The patient must remain in bed for 3 weeks.
STIFFNESS — Stiffness of the shoulder is common but temporary; it results from fear of moving a fracture. Unless the fingers are exercised, they also may become stiff and take months to regain movement.

FRACTURE AT EITHER END

Occasionally the clavicle fractures near one or other end. The injury resembles a subluxation or dislocation of the nearby joint and is treated like such an injury (*see* pages 277–278).

FRACTURED SCAPULA

MECHANISM

The body of the scapula is fractured by a crushing force, which usually also fractures ribs. The neck of the scapula may be fractured by a blow or by a fall on the shoulder.

SIGNS

LOOK — Swelling or bruising may be evident.
FEEL — The scapula is tender.
MOVE — Shoulder movements are painful; breathing also may be painful, and thoracic injury must then be excluded.
X-RAY — The films may show a comminuted fracture of the body of the scapula, or a fractured scapular neck with the outer fragment pulled downwards by the weight of the arm.

TREATMENT

Reduction is impossible and unnecessary. The patient wears a sling for comfort, and from the start practises active exercises to the shoulder, elbow and fingers.

ACROMIOCLAVICULAR JOINT INJURIES

MECHANISM

A fall on the shoulder tears the acromioclavicular ligaments, and upward subluxation of the clavicle may occur; more severe injury also tears the conoid and trapezoid ligaments, permitting dislocation.

CHAPTER 22

FRACTURES AND DISLOCATIONS IN THE UPPER LIMB

THE SHOULDER

THREE principles govern the treatment of injuries round the shoulder.

(*a*) If reduction is unnecessary or impossible, the fracture is disregarded and treatment concentrated on regaining shoulder movement.

(*b*) If reduction is necessary and is possible it may need to be held, and shoulder movements must subsequently be regained by active exercises.

(*c*) In all shoulder injuries, however treated, the elbow and fingers must be exercised from the start.

FRACTURED CLAVICLE

MECHANISM

A fall on the outstretched hand breaks the clavicle; the outer fragment is pulled down by the weight of the arm and the inner half is held up by the sternomastoid muscle.

SIGNS

LOOK — An obvious lump is present.

FEEL — The lump is tender.

MOVE — The patient is reluctant to move the shoulder.

X-RAY — The fracture is usually in the middle third of the shaft, and is transverse to the length of the bone. The outer fragment lies below the inner; often there is a separate central fragment.

TREATMENT

REDUCE — The patient's shoulders are pulled backward without anaesthetic. Accurate reduction is neither possible nor essential

HOLD — Felt rings, which encircle each axilla, are connected posteriorly. The arm is supported in a sling, and the link between the felt loops is tightened daily. Loops and sling are worn for three weeks.

EXERCISE — The elbow, wrist and fingers must be exercised from the start. Active shoulder movements should also be begun early; the patient feels reassured if the fracture is "protected" by the physiotherapist's hand.

When the sling is discarded, full shoulder movements are quickly regained.

If the patient is prepared to accept a small lump, a sling worn for a few days is the only treatment necessary. Full function will be regained, though perhaps not for several months.

EXERCISE — Elbow and fingers are exercised from the start, and the shoulder as soon as possible.

COMPLICATIONS

An unreduced or a recurrent dislocation may trouble the patient. If so, the clavicle may be anchored back to the manubrium sterni with strips of fascia.

Very rarely the inner clavicle is dislocated backwards by a direct blow. Ribs are broken, shock is profound, and dangerous pressure on the trachea or innominate vein may develop quickly. The clavicle must be pulled forwards urgently.

FRACTURED NECK OF HUMERUS

MECHANISM

The patient falls on the arm or hand, usually with the arm abducted. The surgical neck fractures, and the upthrust may shear off the greater tuberosity. Usually the force is sufficient to impact the fragments.

SIGNS

The injury is common in elderly people and not uncommon in adolescents. Between these ages it is rare.

LOOK — The shoulder is swollen and later the arm becomes bruised.

FEEL — The bones cannot be easily palpated, but are tender.

MOVE — Little movement is possible and attempted movement is painful.

X-RAY — In the elderly, a transverse fracture extends across the surgical neck, and often the greater tuberosity also is fractured. The shaft is usually impacted into the head in an abducted position. Occasionally no impaction occurs and the shaft may shift medially

In adolescents, fracture-separation of the upper humeral epiphysis may occur; the shaft shifts upwards and forwards; the head, with a large triangular piece of the metaphysis attached, remains in position.

In children, fracture through the upper humerus is rare; but, when it does occur, is usually through a solitary cyst.

TREATMENT

REDUCE — If there is no displacement, reduction is unnecessary. If there is impaction, reduction is unwise, unless displacement is gross. Even severely displaced fractures rarely need be reduced under anaesthesia.

HOLD — Only a sling is necessary, whether or not reduction has been attempted. The weight of the arm tends to correct displacement.

Union occurs in 3 weeks and consolidation in 6 weeks.

EXERCISE — Elbow and finger movements are practised from the start. Pendulum

SIGNS

LOOK — An unduly high "step" is visible, unless swelling obscures it.
FEEL — The step can be felt. Tenderness is localized to the joint.
MOVE — Shoulder movements are limited by pain.
X-RAY — The films show either a subluxation with only slight elevation of the clavicle, or dislocation with considerable elevation.

TREATMENT

REDUCE — Pressure on the outer end of the clavicle effects reduction.
HOLD — The outer clavicle and the olecranon process are protected with felt pads and firm encircling strapping approximates the padded points. A sling is worn.

This method may fail because there is only a narrow margin between strapping which is too loose to be effective or so tight as to cause skin necrosis. An alternative is to hold the reduction by means of a screw or wires traversing the joint. The operation is rarely advisable, however, for even an unreduced dislocation causes little disability and surgery replaces a lump by a scar.

A subluxation is stable after 3 weeks and a dislocation after 6 weeks.

EXERCISE — The fingers and elbow are exercised from the start, and the shoulder as soon as possible.

COMPLICATIONS

An unreduced subluxation is common and causes no disability.

An unreduced dislocation is common among all-in wrestlers, and clearly need not affect function (the ugly appearance is an advantage in their profession). Sometimes, however, an unreduced dislocation is troublesome, and the outer 1 inch of the clavicle may then be excised.

STERNOCLAVICULAR DISLOCATIONS

MECHANISM

This rare injury is caused by a fall on the shoulder which forces the inner end of the clavicle forwards and upwards.

SIGNS

LOOK — The dislocated inner end of the clavicle forms a prominent lump.
FEEL — Tenderness is localized to the sternoclavicular joint.
MOVE — Shoulder movements are painful.
X-RAY — The films are difficult to interpret, but enable dislocation to be distinguished from a fractured inner end of clavicle

TREATMENT

REDUCE — With the patient anaesthetized, the inner end of the clavicle is pushed into position.
HOLD — Strapping, or a firm pad and bandage, is advised. If the pad or strapping holds the reduction, which is unlikely, it is retained for 6 weeks and a sling is worn.

will be many months before the shoulder moves fully. In all other cases, gentle active shoulder movements should be begun at once, and gradually increased.

SHOULDER DISLOCATION: (A) ANTERIOR

MECHANISM

This very common injury is caused by a fall on the hand. The humerus is driven forward, tearing the capsule or avulsing the glenoid labrum. Occasionally the postero-lateral part of the head is crushed. Rarely, the acromion process levers the head downwards and a luxatio erecta position results; nearly always the arm then drops, bringing the head to its usual subcoracoid position. Uncoordinated muscle action, as in an epileptic fit, may also cause dislocation.

SIGNS

LOOK — The patient supports his arm, which is held abducted and appears too long. The contour is angular, because of the unduly prominent acromion process and the flat deltoid muscle.

FEEL — The humeral head is unduly anterior, but is difficult to feel unless the axilla is palpated.

MOVE — Shoulder movements are impossible.

Note — The limb must always be tested for nerve and vessel injury.

X-RAY — Even if the dislocation is obvious, x-rays are taken to see if a fracture coexists.

TREATMENT

REDUCE

Modern method — The patient is relaxed under anaesthesia. An assistant pulls the arm, while the surgeon easily thumbs the head into place.

Other methods — The surgeon places his stockinged foot into the patient's axilla, pulls the arm and levers the head of the humerus into position (Hippocrates). Alternatively, the surgeon pulls on the flexed elbow, abducts and rotates the humerus outwards, then adducts it while rotating it inwards (Kocher).

An x-ray picture is taken to confirm reduction and exclude a fracture.

HOLD — When the patient is fully awake, active abduction is gently tested; if abduction is impossible, there may be a circumflex nerve palsy or supraspinatus tendon avulsion. In either case an abduction frame may be indicated. In the absence of these complications probably only a sling is necessary; but if the surgeon also bandages the arm to the trunk for 3 weeks, he cannot be blamed if dislocation becomes recurrent.

EXERCISE — Elbow and finger movements are started at once. Shoulder movements are actively regained when the sling and bandage are removed.

COMPLICATIONS

MUSCLE — A torn supraspinatus tendon should be recognized early and treated by splinting the arm on an abduction frame for 6 weeks or occasionally repaired operatively.

NERVE — Nerve injury is common and usually affects the circumflex nerve. It should be recognized before reduction by demonstrating a small patch of anaesthesia over the

exercises of the shoulder are also begun at once, and the patient is encouraged to abduct the arm actively as soon as possible. Especially in the elderly, is it important to concentrate on regaining shoulder movements rather than on treating the fracture.

COMPLICATIONS

STIFFNESS — Stiffness of the shoulder is common and important, but is minimized by early and persistent exercises. It is important to distinguish stiffness following a fracture from that of a "frozen" shoulder (*see* page 123). Finger stiffness is due to neglect.

MAL-UNION — Mal-union is not uncommon. In the elderly it causes little disability; in the adolescent the bone grows straight. (Occasionally a fracture-separation in an adolescent is so severely displaced that, if the patient is nearing the end of growth, it may be thought worthwhile to attempt manipulative reduction and, if this fails, to reduce the fracture operatively: interposed soft tissues are removed and reduction held with a screw.)

FRACTURED GREATER TUBEROSITY

MECHANISM

The greater tuberosity may sustain a "direct" injury when the patient falls on the abducted arm, and the tuberosity impinges against the acromion process. Occasionally an "indirect" or avulsion injury occurs in a young adult who is trying to save himself from falling, when the action of the supraspinatus muscle is resisted by an obstacle; the tuberosity is then pulled off (the force is like that which tears the supraspinatus tendon in middle life).

SIGNS

LOOK — The shoulder is a little swollen.

FEEL — The tuberosity is tender.

MOVE — Abduction is impossible or limited

X-RAY — The tuberosity is usually undisplaced; it is demarcated from the shaft by a fracture line, or is comminuted Occasionally the tuberosity is avulsed by the supraspinatus tendon; it is pulled upwards and appears as a thin slice of bone just under the acromion process.

TREATMENT

REDUCE — In the absence of displacement reduction is unnecessary. The rare displaced fracture is difficult to reduce but reduction is important. Watson-Jones advises bringing the humerus into contact with the tuberosity by abducting 90 degrees, externally rotating 60 degrees, and forwardly flexing 40 degrees.

HOLD — If the reduction described above has been carried out, the arm is maintained in this position by an abduction frame. Union takes 6 weeks, after which the angle of the frame is gradually lowered, and it is discarded at 12 weeks

The commoner undisplaced fractures do not need to be held: the arm is merely rested in a sling.

EXERCISE — The elbow and fingers are exercised from the start. When a frame has been used, shoulder movements must be regained after the splint has been discarded; but it

of overlap (Putti-Platt). (*b*) The anterior edge of the glenoid fossa is rawed and small holes drilled in it; through these the labrum and capsule are reattached by sutures (Bankart). The subscapularis muscle is sutured with slight overlap. After either procedure the coracoid process is replaced, the skin closed and the arm bandaged to the side for 5 weeks.

JOINT STIFFNESS AFTER DISLOCATION

There are two reasons why, following dislocation, a shoulder may fail to regain full movement.

IMMOBILIZATION IN SLING POSITION — After a shoulder injury the arm is usually rested in a sling, which necessarily holds the shoulder in internal rotation. Damaged capsule or muscle, if splinted in this position, soon loses the ability to stretch, especially in patients of over 40 years. There is consequent loss of external rotation, which automatically limits abduction.

Treatment — Early active movements prevent stiffness. Passive exercises are never allowed; they may cause or aggravate traumatic myositis. Active exercises can usually cure stiffness if immobilization has not been prolonged. They are practised vigorously, bearing in mind that full abduction is not possible until external rotation has been regained. Manipulation under anaesthesia is advised only if progress has halted and at least 6 months have elapsed since injury. External rotation should be restored before abduction, and the manipulations should be gentle and repeated rather than forceful.

UNREDUCED DISLOCATION — Surprisingly, a dislocation of the shoulder sometimes remains undiagnosed.

Treatment — Closed reduction is worth attempting up to 6 weeks after injury; manipulation later may fracture the bone or tear vessels or nerves.

Operative reduction is indicated after 6 weeks only in the young, because it is difficult, dangerous and followed by prolonged stiffness. An anterior approach is used, and the vessels and nerves carefully identified before the dislocation is reduced. "Active neglect" summarizes the treatment of unreduced dislocation in the elderly. *The dislocation is disregarded and gentle active movements encouraged.* Moderately good function is often regained.

SHOULDER DISLOCATION: (B) POSTERIOR

MECHANISM

This exceedingly rare injury, which is not a complete dislocation but a fracture-subluxation, is probably caused by forced internal rotation of the abducted arm.

SIGNS

LOOK — Seen from the front the deformity is obscured by swelling, but when it is seen from above the anterior aspect of the shoulder appears unduly flat.

FEEL — The posteriorly displaced head of the humerus is difficult to feel, but the coracoid process is unduly prominent.

MOVE — No movement is possible.

X-RAY — In the antero-posterior view the humeral head is abnormal in shape but, because it is in contact with the glenoid fossa, the injury is easily missed. A lateral view shows posterior subluxation and a fracture of the humeral head.

deltoid muscle insertion, or soon after reduction by the patient's inability to abduct the arm. The lesion is usually a neurapraxia which recovers spontaneously; the use of an abduction frame is customary but probably does not influence recovery.

BONE — Dislocation may be accompanied by a fracture. (*a*) The greater tuberosity may be sheared off during dislocation. It usually falls into place during reduction, and no special treatment is then required. If it has been avulsed and remains displaced, the arm is rested on an abduction frame for 6 weeks. (*b*) The neck of the humerus may fracture with the initial injury or during unskilled reduction. The combined lesion is known as a fracture-dislocation. The detached head remains dislocated and capsized; it may undergo avascular necrosis. Closed reduction is attempted, using the same method as for an uncomplicated dislocation, and if it succeeds, treatment is similar. If closed reduction fails, open reduction should be attempted only in the young, for it is difficult and dangerous; in the elderly, it is better to leave the dislocation and to try to regain some movement.

JOINT — Following dislocation, the joint may remain unstable (recurrent dislocation) or unduly stiff. These complications are considered separately.

RECURRENT DISLOCATION

PATHOLOGY

In 80 per cent of patients with recurrent dislocation, a bony defect in the postero-lateral aspect of the head of the humerus can be demonstrated at operation; in 90 per cent, the capsule is found to be detached from the labrum or the labrum from the glenoid. (Obviously, a bony, and a soft-tissue lesion often coexist.)

These lesions were presumably sustained at the initial injury and it is alleged that they would have healed if early movements had been prevented.

CLINICAL FEATURES

The history is diagnostic. The patient complains that the shoulder dislocates with relatively trivial everyday actions Usually he can reduce the dislocation himself. Any doubt as to diagnosis is quickly resolved by one simple test: if the patient's arm is passively placed behind the coronal plane in a position of abduction and external rotation, his immediate resistance and apprehension are pathognomonic.

In some cases the bony defect can be demonstrated on an anteroposterior x-ray taken with the shoulder abducted 70 degrees and in full internal rotation.

TREATMENT

Conservative treatment is useless An operation which uses an anterior approach to the shoulder is almost uniformly successful.

OPERATION — A vertical incision 5 inches long is used, and extends from the clavicle downwards along the deltopectoral cleft. The deltoid and pectoralis major muscles are separated, exposing the coracoid process, this is divided near its base and reflected downwards together with its attached muscles. The subscapularis muscle and the capsule are divided vertically 1 inch from their insertion. One of two methods is used for repair. (*a*) The capsule and the subscapularis muscle are each sutured with 1 inch

HOLD — To increase the feeling of stability, a U-slab of plaster may be bandaged on; with high fractures the loop of the U is uppermost over the acromion process and with low fractures the loop is round the olecranon process. Alternatively the arm may be bandaged to the trunk. Within a week the slab or trunk bandage is removed, and the forearm is supported in a "wrist sling" with the elbow at 90 degrees. The patient spends the day sitting bolt upright or standing, and he is propped vertically at night.

The fracture unites in about 6 weeks and is consolidated in about 12 weeks, after which the sling is discarded.

EXERCISE — The wrist and fingers are exercised from the start. The patient is taught to contract the elbow flexors and extensors actively. Pendulum exercises of the shoulder are begun within a week, but active abduction of the shoulder is postponed until the fracture is clinically and radiologically consolidated.

COMPLICATIONS

RADIAL NERVE PALSY — Radial nerve palsy is usually temporary. A "lively" splint is used to support the wrist and hand while recovery is awaited. If recovery does not occur, nerve repair or tendon transplants may be required (*see* page 98).

DELAYED UNION — Delayed union occurs in transverse fractures if excessive traction has been used (for example, a hanging cast) or if the patient has not actively exercised the elbow flexors and extensors. The forearm sling must be retained until consolidation is complete, and repeated contractions of the elbow muscles must be practised.

NON-UNION — Non-union occurs only in transverse fractures; it may be due to failure to recognize and treat delayed union, or to the dangerous combination of incomplete union and a stiff joint. If elbow or shoulder movements are forced before consolidation of the fracture, it will angulate and may proceed to non-union.

The treatment of established non-union is operative. The bone ends are freshened, bone chips packed around them and an intramedullary nail inserted or a plate screwed on.

JOINT STIFFNESS — Joint stiffness may be minimized by early activity, but transverse fractures (in which shoulder abduction is dangerous) may limit shoulder movement for several months.

THE ELBOW

In the elbow region, the fractures which occur in children are quite different from those occurring in adults. Beneath the heading of each individual fracture is indicated whether it occurs in childhood or in adult life.

SUPRACONDYLAR FRACTURE: (A) BACKWARDS
(Children)

MECHANISM

This common injury is caused by a fall on the hand with the elbow bent. The humerus breaks just above the condyles. The distal fragment, with the forearm, is pushed backwards.

TREATMENT

REDUCE — The arm is pulled and rotated outwards while the head of the humerus is pushed forwards.
HOLD — The shoulder is held widely abducted and externally rotated in a plaster spica for 3 weeks.
EXERCISE — Shoulder movement is regained by active exercises.

COMPLICATIONS

Following posterior dislocation, the joint may be unstable (recurrent dislocation) or unduly stiff.

RECURRENT DISLOCATION — Recurrent posterior dislocation can occur. Through a posterior approach the capsule is repaired with overlap, and the shoulder held abducted and externally rotated for 6 weeks.
UNREDUCED DISLOCATION — Unreduced dislocation in the young may be reduced operatively through a posterior incision. In the elderly it is disregarded.

SHAFT OF HUMERUS

MECHANISM

A fall on the hand may twist the humerus, causing a spiral fracture. A fall on the elbow with the arm abducted may hinge the bone causing a slightly oblique or transverse fracture. A heavy blow on the arm causes a fracture which is either transverse or grossly comminuted.

SIGNS

LOOK — Deformity, swelling and bruising may be obvious.
FEEL — The arm is tender.
MOVE — The patient is unwilling to move the arm. Finger extension should be tested in order to exclude a musculospiral nerve lesion.
X-RAY — The films show the site of the fracture in the shaft, its line (spiral, transverse or comminuted) and any displacement.

TREATMENT OF SPIRAL OR COMMINUTED FRACTURE

REDUCE — Neither anaesthesia nor manipulation is needed for reduction (*see* below).
HOLD — The distal forearm is supported in a "wrist sling" with the elbow at 90 degrees of flexion Providing the elbow is unsupported, gravity exerts sufficient traction to effect reduction and to maintain it. The fracture unites in about 3 weeks and is consolidated in 6 weeks, after which the sling is discarded.
EXERCISE — Wrist and finger exercises are begun at once. To minimize shoulder stiffness the patient is taught to lean forwards at the hips, and, with the arm hanging supported only by its wrist sling, to practise gentle pendulum exercises. When the fracture is "sticky" active abduction of the shoulder may safely be practised.

TREATMENT OF TRANSVERSE OR SHORT OBLIQUE FRACTURE

REDUCE — Only if the fracture is grossly angulated is manipulative reduction advisable, and it is not essential.

which returns gradually with use. Passive movements are prohibited at all times; the elbow must never be pulled, pushed or passively stretched by carrying weights.

The shoulder need not be exercised, for in a child it will not stiffen.

COMPLICATIONS

The prognosis of supracondylar fractures is usually very good, but the following complications may occur.

VOLKMANN'S ISCHAEMIA — This must always be watched for. If there is undue pain, altered colour or diminished sensation of the fingers, or an absent pulse, or pain on straightening the fingers, urgent action is necessary (*see* page 266).

JOINT STIFFNESS — Joint stiffness is common, and the elbow may not extend fully for many months; extension must never be forced. In the first few weeks elbow stiffness may be due to myositis ossificans. Passive or forced movements are prohibited at all times and, at the first sign of diminished movement or of calcification, the elbow is rested in a plaster gutter (*see* page 271).

MAL-UNION — Mal-union is common. With backward or sideways shift, the humerus gradually grows straight. Forward or backward tilt may limit flexion or extension, but consequent disability is slight.

Uncorrected sideways tilt or rotation may lead to a varus deformity, which is ugly and sometimes requires osteotomy; or to a valgus deformity, which may cause late ulnar palsy. Epiphyseal damage is often blamed for these deformities, but usually faulty reduction is responsible.

NERVE INJURIES — Nerve injuries are common; they usually recover spontaneously.

SUPRACONDYLAR FRACTURE: (B) FORWARDS
(Children)

MECHANISM

This rare injury is caused by a fall on the hand with the elbow *straight.* *The humerus* breaks just above the growth disc and the fragment is tilted forwards.

SIGNS

LOOK — Altered contour and swelling are seen.

FEEL — Tenderness is felt at and above the elbow.

MOVE — The child is asked to move the fingers so that nerve injury can be excluded.

X-RAY — The fracture line is oblique and is lower posteriorly. To assess the forward tilt a line may be drawn down the front of the humeral shaft; normally its projection should bisect the epiphysis.

TREATMENT

REDUCE — The arm is pulled and the elbow fully *straightened.*

HOLD — A posterior slab is bandaged on, *holding the elbow straight.* After 3 weeks the slab is removed.

EXERCISE — The child is allowed to regain elbow flexion gradually.

SIGNS

LOOK — The child holds his forearm with the other hand. Until swelling obscures the details, the backward shift just above the elbow is apparent.

FEEL AND MOVE — It is unkind to palpate the fracture or to attempt elbow movement. In every elbow injury, however, it is essential to feel the pulse and to examine the hand for evidence of injury to arteries or nerves.

X-RAY — The lateral view shows a fracture just above the growth disc. The line of fracture runs obliquely and is lower anteriorly. The fragment and the forearm are shifted backwards and tilted backwards.

An antero-posterior film may be difficult to obtain without hurting the child. If so, it is postponed until the child has been anaesthetized prior to the reduction. It often shows that the distal fragment is shifted and tilted sideways, and is twisted (usually inwards).

TREATMENT

REDUCE — Reduction must be carried out methodically with the child relaxed under anaesthesia

(1) With his left hand the surgeon pulls on the child's forearm and maintains traction for 1 minute. (2) Without releasing traction he grasps the distal fragment with his right hand and corrects sideways shift, tilt and twist. (3) He then flexes the elbow while pushing the lower humerus forwards with his right thumb. The intact triceps muscle prevents over-reduction. (4) The radial pulse is then palpated. If it cannot be felt, the elbow must be extended a few degrees until the pulse returns, then a further 10 degrees for safety. (5) Antero-posterior and lateral films are taken to confirm reduction. The elbow must not be straightened for the antero-posterior film, which should be taken through the flexed upper forearm. Slight shift may be accepted, but tilt or twist should be fully corrected. If necessary, the manipulations are repeated. Even if closed reduction is not completely successful, open reduction is never advised.

HOLD — A collar and cuff is applied to hold the elbow flexed. The more the elbow is flexed, the more stable the reduction is, and during the next few days, as swelling subsides, the link between the collar and the cuff is tightened, providing the pulse remains palpable.

Occasionally the elbow cannot be sufficiently flexed without obliterating the pulse. A less flexed position, at which the pulse is palpable, must be accepted, and a posterior plaster slab is used in addition to the collar and cuff. The slab extends two-thirds of the way round the limb, from below the shoulder to above the wrist, and is held on with a crêpe bandage A few days later the plaster is removed, the elbow flexed further, and x-rays taken; occasionally remanipulation proves necessary.

Union takes 3 weeks; during this time the hand must not be taken out of the cuff and the limb is kept beneath the shirt. For the succeeding 3 weeks (until consolidation) the limb is supported outside the clothing

EXERCISE — For the first 3 weeks, only finger and wrist movements are practised.

After 3 weeks the child may take his hand out of the cuff during supervised activities, such as washing, dressing and writing. Elbow flexion is encouraged, but not extension,

MOVE — Flexion is grossly limited and painful.

X-RAY — In the lateral view the capitellum is seen in front of the lower humerus.

TREATMENT

REDUCE — While the arm is being pulled straight an attempt is made to thumb the fragment back into position.

If closed reduction fails operation is essential, or flexion will remain permanently limited. The elbow is approached from the outer side. Loose flakes of cartilage are removed and the capitellum is replaced and sutured in position with catgut. (The capitellum should never be removed even if it is totally detached.)

HOLD — *A posterior slab is applied with the elbow at 90 degrees or slightly more flexed*; but, if reduction appears unstable at this angle, a more extended position is permissible.

The plaster slab is retained for 1–3 weeks according to the stability of the reduction. A collar and cuff is then worn up to 6 weeks from the injury.

EXERCISE — *The shoulder, wrist and fingers must be exercised from the start.* Elbow movements are regained by active use when plaster has been removed.

MINOR INJURIES

Minor injuries of the capitellum are not uncommon. Only the articular cartilage is damaged and no change is seen on x-ray. This may be the underlying cause of osteochondritis dissecans.

FRACTURE-SEPARATION OF LATERAL CONDYLAR EPIPHYSIS

(Children)

MECHANISM

The child falls on the hand with the elbow slightly varus. A large fragment, which includes the lateral condyle, breaks off and is pulled upon by the attached wrist extensors. In severe injuries probably the elbow dislocates postero-laterally; the condyle is "capsized" by muscle pull and remains capsized while the elbow reduces spontaneously.

SIGNS

LOOK — The elbow is swollen.

FEEL — There is tenderness over the outer side.

MOVE — Movements of the elbow or *wrist are painful.*

X-RAY — Displacement may be slight, or the condyle grossly rotated. A triangular fragment of metaphysis may be displaced with the condyle. It is often valuable to compare the films with those of the normal elbow.

TREATMENT

REDUCE — Slight displacement is probably unimportant. If the condyle is capsized, reduction is essential. The forearm is pushed postero-laterally, as if to reproduce the dislocation, then pulled forwards again. This manœuvre feels unconvincing but is often successful. (McLearie and Merson, 1954.)

COMPLICATIONS

If the fracture has not been reduced, extension remains limited but the disability is rarely severe.

T-SHAPED AND Y-SHAPED FRACTURES
(Adults)

MECHANISM

A fall on the point of the elbow may drive the olecranon process upwards, splitting the condyles apart.

SIGNS

LOOK — The elbow is grossly swollen.
FEEL — Palpation is painful and unnecessary.
MOVE — The patient is unwilling to move the elbow.
X-RAY — The films show a fracture of the lower humerus extending into the elbow joint. The line of the fracture is a "T" or a "Y", or comminution may be seen. Often the condyles are separated, and either may be tilted in any direction.

TREATMENT

ORTHODOX TREATMENT — The forearm is pulled in the straight position and the bones moulded into shape. A posterior plaster slab, bandaged on with the elbow a little straighter than a right angle, is retained for 6 weeks. The shoulder, wrist and fingers are exercised from the start. When the plaster is removed the patient tries to regain elbow flexion.

TREATMENT BY ACTIVITY — The orthodox treatment usually leaves a permanently stiffish elbow, and if flexion is much limited, the disability is considerable. If comminution has occurred, it is probably better to disregard the fracture and to concentrate on the joint. The arm is held above a right angle in a collar and cuff Active movements are encouraged, and often mould the fragments into reasonable position. The final range is usually better than expected.

OPERATIVE TREATMENT — In the absence of comminution, operation is occasionally worth while. The elbow is approached from the outer side, and the condyles are reduced and held with a screw. The procedure must be a small and limited one or stiffness is inevitable.

FRACTURED CAPITELLUM
(Adults)

MECHANISM

The patient falls on the hand with the elbow straight or in slight varus position. The anterior half of the capitellum and the trochlea are sheared off and displaced proximally.

SIGNS

LOOK — Fullness is seen in front of the elbow.
FEEL — The elbow is tender.

unless the nerve is allowed to remain kinked in the joint. Occasionally a later palsy develops because of friction against the roughened bony groove.

FRACTURED NECK OF RADIUS
(Children)

MECHANISM

The child falls on the outstretched hand while the elbow is slightly valgus.

SIGNS

LOOK — The elbow is only slightly swollen.
FEEL — There is tenderness over the outer side.
MOVE — Rotation is painful.
X-RAY — The fracture line is transverse. It is either situated immediately distal to the growth disc, or there is true separation of the epiphysis with a triangular fragment of shaft. The proximal fragment is tilted forwards and outwards.

TREATMENT

REDUCE — The arm is pulled into extension and slight varus. With his thumb the surgeon pushes the displaced fragment medially and backwards.

Reduction is essential or permanent limitation of movement results; therefore, if closed reduction fails, the fragment must be reduced at open operation. The head of the radius must never be excised in children or the ulna will outgrow the radius; the inferior radio-ulnar joint then subluxates and rotation becomes limited.

HOLD — A posterior plaster slab extending two-thirds of the way round the limb is bandaged on. It is usual for the elbow to be held in 90 degrees of flexion, but the angle at which reduction seems stable should be maintained.

The slab is worn for 3 weeks, and a collar and cuff for a further 3 weeks.

EXERCISE — The elbow is allowed to regain movement spontaneously after the collar and cuff has been removed.

FRACTURED HEAD OF RADIUS
(Adults)

MECHANISM

A fall on the outstretched hand forces the elbow into valgus position and pushes the radial head against the capitellum. The radial head may be split or broken. In addition, the articular cartilage of the capitellum may be bruised or chipped; this cannot be seen on x-ray but is an important complication.

SIGNS

LOOK — Swelling may be only slight.
FEEL — The head of the radius is tender.
MOVE — Rotation of the forearm is painful.
X-RAY — The films may show (*a*) a vertical split in the radial head; (*b*) a single fragment of the lateral portion of the head broken off and usually displaced distally; or (*c*) the broken into several fragments.

If closed reduction fails operation is essential. The fragment is exposed, replaced in position and held with catgut sutures.

HOLD — A posterior plaster slab is applied, extending from below the shoulder to just short of the knuckles, with the elbow just above 90 degrees flexion and the wrist dorsiflexed (to relax the extensor muscles). After 3 weeks, the fracture will have united. The plaster is then removed but a collar and cuff is worn for a further 3 weeks.

EXERCISE — The fingers and shoulder are exercised from the start. Elbow and wrist movements are regained later.

SEPARATION OF MEDIAL EPICONDYLAR EPIPHYSIS

(Adolescents)

MECHANISM

The patient falls on the hand while the elbow is extended and slightly valgus, so that it is forcibly abducted. The medial epicondylar epiphysis is pulled distally by the attached wrist flexors. With more severe injuries the medial ligament of the elbow tears, the joint dislocates laterally and the epiphysis is pulled into the joint. The elbow may remain dislocated, or may reduce spontaneously and trap the epicondyle.

SIGNS

LOOK — If the joint is dislocated deformity is obvious.

FEEL — The inner side of the joint is tender. The ulnar fingers must be palpated to exclude ulnar nerve damage.

MOVE — Attempted movement is painful.

X-RAY — In the antero-posterior view, the medial epicondylar epiphysis may be seen tilted or shifted downwards; if the joint is dislocated the epiphysis lies distal to the lower humerus. A lateral view may show the epicondyle looking like a loose body in the joint.

TREATMENT

REDUCE — Minor displacement may be disregarded. An epicondyle trapped in the joint must be freed. Manipulation with the elbow pulled into valgus position is sometimes successful. Another possible manœuvre is to hold the fingers extended and apply a faradic current to the forearm flexors, which may then pull the fragment out of the joint. If closed methods fail operation is essential. An incision is made on the medial aspect of the elbow and the ulnar nerve, which may be kinked into the joint, is carefully exposed. The epicondyle is replaced in position or excised. The medial ligament of the elbow is repaired and the ulnar nerve transposed to the front of the elbow.

HOLD — A collar and cuff is worn for 3 weeks

EXERCISE — The shoulder is exercised from the start and elbow range is regained when the collar and cuff has been removed.

COMPLICATIONS

ELBOW STIFFNESS — Stiffness of the elbow is common. Extension may remain limited for several months, but must not be forced. Full movement returns eventually, providing the epicondyle has not been left in the joint

ULNAR NERVE DAMAGE — Ulnar nerve damage may have occurred, but it usually recovers

SIGNS

LOOK — Swelling behind the elbow may be seen.
FEEL — The gap in the bone is sometimes palpable.
MOVE — The patient cannot extend the elbow against resistance.
X-RAY — The fracture is transverse and the avulsed fragment is pulled proximally.

CLOSED TREATMENT

The fracture can usually be reduced by straightening the elbow, but reduction can be held only if the straight position is maintained in plaster for several weeks, and stiffness in the straight position is a disaster. This method is therefore rarely employed. If the fracture is disregarded and the arm rested in a sling, a long fibrous union results; the elbow regains full range but loses power. This method is suitable only for elderly patients unfit for operation.

OPERATIVE TREATMENT

Operative treatment is the method of choice; its aim is to repair the extensor mechanism. The olecranon process is exposed, carefully reduced, and held by a long screw driven through it into the shaft of the ulna. If the fragment is small it may be excised and the triceps tendon reattached to the ulna.
After operation a sling is worn for 3 weeks.

ELBOW DISLOCATION
(Children or Adults)

MECHANISM

A fall on the hand may dislocate the elbow. The forearm is pushed backwards. Once posterior dislocation has taken place, lateral shift may also occur.

SIGNS

LOOK — The patient supports the forearm with his other hand. Deformity and swelling are obvious.
FEEL — The olecranon process can be readily felt out of its normal position. The pulse must be examined and sensation in the fingers tested.
MOVE — No movement is possible.
X-RAY — Even though the dislocation is clinically obvious, x-ray films must be taken to exclude an associated fracture.

TREATMENT

REDUCE — The patient should be fully relaxed under anaesthesia. The surgeon pulls on the forearm while the elbow is slightly flexed. With one hand, sideways displacement is corrected, then the elbow is further flexed while the olecranon process is pushed forward into position.

HOLD — The arm is held in a collar and cuff with the elbow flexed above 90 degrees. After 1 week the patient may gently exercise his elbow for a few minutes at a time. At 3 weeks he may discard the collar and cuff.

CLOSED TREATMENT

Only when the injury is a simple vertical split should closed treatment be used. The arm is held in a collar and cuff for 3 weeks. Active flexion and extension may be encouraged and rotation allowed to return by itself.

OPERATIVE TREATMENT

A severe fracture should be treated by excision of the entire radial head.

TECHNIQUE — A tourniquet is applied, the elbow is flexed and an incision $1\frac{1}{2}$ inches long is made extending from the lateral epicondyle towards the thumb. The capsule is incised and the radial head completely removed. The excised portions should be fitted together to ensure that no fragment has been left behind. The capsule and the skin are sutured. Aftercare is the same as that following closed treatment.

COMPLICATIONS

JOINT STIFFNESS — *Joint stiffness is common and may involve both the elbow and the* radio-ulnar joints. Occasionally myositis ossificans develops. Stiffness may occur whether the radial head has been excised or not. Probably, however, the prognosis is better after operation.

FRACTURED OLECRANON: (A) COMMINUTED FRACTURE
(Adults)

MECHANISM

A direct blow or fall on the point of the elbow may cause a comminuted fracture of the olecranon process, but there is usually little displacement.

SIGNS

LOOK — The point of the elbow is bruised or grazed.

FEEL — There is localized tenderness.

MOVE — *The triceps muscle is intact and the elbow can be extended against resistance.*

X-RAY — *The olecranon process may be broken into several fragments, but usually there* is little displacement.

TREATMENT

The injury should be treated as a bruise and the fracture disregarded. A sling is worn for comfort and active movements encouraged.

FRACTURED OLECRANON: (B) TRANSVERSE ("GAP")
(Adults)

MECHANISM

The patient falls onto the hand while the triceps muscle is in action. The olecranon process fractures transversely and its proximal portion is pulled upwards by the triceps muscle.

MOVE — Movement should not be attempted.

X-RAY — Both bones are broken, either transversely and at the same level, or obliquely with the radial fracture usually at a higher level. In children, the fracture is often incomplete (greenstick) and only angulated. In adults, displacement may occur in any direction—shift, overlap, tilt or twist.

CLOSED TREATMENT

REDUCE — A greenstick fracture is easily reduced by firm pressure.

A complete fracture, whether spiral or transverse, is reduced by traction and rotation. The elbow is bent and the surgeon pulls on the hand while an assistant resists the pull by holding the upper arm. While traction is maintained the hand is rotated until the fragments are aligned.

In adults, perfect reduction is essential; in children slight overlap is unimportant, providing no angulation or rotation deformity persists.

HOLD — While traction is maintained, plaster is applied from just below the axilla to just above the knuckles. The elbow is held at 90 degrees and the wrist dorsi-flexed. The forearm should be in midrotation unless the radial fracture is high, when the forearm should be supinated. X-ray films are taken to confirm reduction.

As soon as the plaster has set it is split from top to bottom to expose the skin. The patient is returned to the ward, and his arm elevated. When swelling has subsided, the plaster is completed or renewed.

In adults, a spiral fracture usually consolidates in 6 weeks, and a transverse fracture in 12 weeks; in children, these times are considerably shorter. When consolidation may be expected to have occurred, the plaster is removed and the fracture assessed clinically and radiologically. Unless consolidation has occurred a complete plaster must be reapplied.

EXERCISE — Shoulder and finger movements are practised from the start. When the plaster is removed the patient wears a sling and regains elbow and radio-ulnar movements by graduated activity.

OPERATIVE TREATMENT

In compound fractures, wound toilet is of course necessary; during the operation the fracture is reduced under direct vision, but the bones should not be plated.

With closed fractures in adults, perfect function cannot be ensured unless perfect reduction has been achieved. If closed reduction has failed operation is advisable. Closed reduction is so often difficult in an adult that many surgeons prefer to operate without delay.

REDUCE — The fractures are exposed by two separate incisions, one for each bone (if one incision only is used, there is danger of cross union). An assistant pulls on the arm and rotates it, while the surgeon reduces the fracture under direct vision.

HOLD — The fracture in each bone is held by means of a plate and screws. A well moulded plaster slab is bandaged on; it extends two-thirds of the way round the arm and from below the shoulder to above the knuckles.

Consolidation takes just as long as if the fractures had not been plated, and the usual

EXERCISE — Shoulder and finger exercises are begun at once. Elbow movements are allowed to return spontaneously and are never forced.

COMPLICATIONS

ASSOCIATED FRACTURES — Associated fractures are common.

Coronoid process — Small flake fractures of the coronoid process are unimportant and require no special treatment.

Head of radius — This fracture, combined with dislocation, is a serious injury. The dislocation is first reduced; 10 days later the head of the radius is excised.

Olecranon process — Rarely, the elbow dislocates forwards, leaving the proximal one inch of the olecranon process behind as a separate fragment. Although the combined injury can be treated by reduction and plaster in full extension, it is probably better to ensure stability by fixing the olecranon process with a screw.

"*Side-swipe*" *fracture-dislocation* — This term is used by Watson-Jones to describe the injury sustained when a driver sticks his elbow out of the window and the elbow is struck by another car. The result is forward dislocation with fractures of any or all of the bones. It is best to reduce the dislocation first, then hold it reduced in a split plaster, and treat the fractures when the joint becomes stable.

Medial epicondyle — The association of this fracture with a lateral dislocation of the elbow has already been described (*see* page 290).

JOINT STIFFNESS — This may be due to one of the following causes.

Myositis ossificans — To minimize the risk of this complication, passive movements must be prohibited. If movement is diminishing, or if x-rays show calcification, the elbow should be rested in a plaster gutter (*see* page 271).

Unreduced dislocation — A dislocation may not have been diagnosed; or only the backward displacement corrected, leaving the olecranon process still displaced sideways. Up to 6 weeks from injury, manipulative reduction is worth attempting; after that the dislocation is best left Often a useful range of movement is regained, but if the elbow remains stiff and painful, arthroplasty may be considered.

NERVE INJURIES — These are not uncommon. They usually recover.

THE FOREARM

FRACTURED RADIUS AND ULNA

MECHANISM

A twisting force (commonly a fall on the hand) causes a spiral fracture with the bones broken at different levels. A direct blow or an angulating force causes a transverse fracture of both bones at the same level. Additional rotation deformity may be produced by the pull of muscles attached to the radius: they are the biceps and supinator muscles to the upper third, the pronator teres to the middle third, and the pronator quadratus to the lower third.

SIGNS

LOOK — Deformity is usually obvious. The fracture may be compound.

FEEL — The fracture sites are tender. The pulse should be tested.

though both forearm bones were broken. The fracture is transverse and it may be 12 weeks before consolidation is complete.

EXERCISE — Exercises, as for fractures of both bones, are carried out.

OPERATIVE TREATMENT

Many surgeons advise internal fixation by a plate and screws. A plated ulna probably needs no plaster, but a plated radius in a manual worker must be protected by a plaster which includes the elbow and wrist.

FRACTURE-DISLOCATION: (A) UPPER (MONTEGGIA)

MECHANISM

Usually the cause is a fall on the hand; if at the moment of impact the body is still twisting, its momentum may forcibly pronate the forearm. The radial head dislocates forwards and the upper third of the ulna fractures and bows forwards.

A direct blow (as with a knobkerry) may cause a similar displacement or may cause the rare backward dislocation of the radial head with backward bowing of the ulna.

SIGNS

LOOK — The ulnar deformity is usually obvious but the dislocated head of the radius is masked by swelling.

FEEL — Both the fracture and the dislocation can usually be felt.

MOVE — Attempted movement is painful.

X-RAY — In the common forward type, the head of [illegible] there is a fracture of the upper third of the ulna w[illegible]

In the rare backward type, the head of the rad[illegible] ulnar fracture bowed backwards.

CLOSED TREATMENT

REDUCE — The ulna can easily be reduced by traction followed by full supination of the forearm. The radial head slips into place if the ulna has been perfectly reduced.

HOLD — Plaster is applied, extending from the axilla to the knuckles. Most Monteggia fracture-dislocations are best held with the elbow at 90 degrees flexion and the forearm fully supinated; with the rare backward type an extended position is usually necessary.

Consolidation of the ulnar fracture usually takes about 12 weeks, and the plaster must be retained until it occurs.

EXERCISE — The shoulder and fingers are exercised from the start. Elbow and radio-ulnar movements take many months to return; they must not be forced.

OPERATIVE TREATMENT

If closed reduction fails, or cannot be held stable, operation is necessary. Moreover, operation with firm internal fixation lessens the period of disability.

The ulna is exposed and reduced under direct vision. It is held reduced by a plate and screws or by an intramedullary nail. With perfect reduction of the ulna, the dislocation of the radial head is reduced automatically. After operation, the

practice, once the wounds have healed, is to replace the plaster slab by a complete plaster for 12 weeks.

EXERCISE — Plated forearm fractures are eminently suited to the "delayed splintage" technique: the day after operation a physiotherapist removes the slab and, under her supervision, the patient actively exercises all joints. The slab is replaced immediately after treatment, which is carried out twice daily until the wounds have healed. A complete plaster is then applied and, when it is removed, full movement is rapidly regained.

Very occasionally an open reduction may be desirable in a child, but plating is never used.

COMPLICATIONS

ISCHAEMIA — Ischaemia, especially affecting the hand, must be watched for.

NON-UNION — This may occur if the plaster has been removed before consolidation. In the radius, non-union is treated by freshening the bone ends and screwing on a bone graft; plaster is then applied. In the ulna, the bone ends are freshened and either a plate or an intramedullary nail is used.

MAL-UNION — Mal-union is usually due to redisplacement within a loose plaster. The arm may look ugly and rotation is limited. Operative correction and plating may be necessary.

JOINT STIFFNESS — Joint stiffness affecting the elbow and radio-ulnar joint may be unavoidable but, unless there is mal-union, full movement will be regained with activity. Shoulder and finger stiffness result from neglect.

FRACTURES OF ONE BONE ONLY

Fracture of the radius alone, or of the ulna alone is uncommon. It is important for two reasons: (*a*) an associated dislocation may be undiagnosed; if only one forearm bone is broken and there is displacement, one or other radio-ulnar joint must be dislocated; as a precaution the entire forearm must always be x-rayed; (*b*) non-union, especially of the radius, is liable to occur unless it is realized that one bone takes just as long to consolidate as two.

MECHANISM

The usual cause is a direct blow on the forearm.

SIGNS

LOOK — Only slight swelling is seen, and no obvious deformity.

FEEL — Tenderness is localized to the fracture site

MOVE — With a fracture of the radius rotation is painful.

X-RAY — The fracture may be anywhere in the radius or ulna. Usually either the upper end of the ulna or the lower end of the radius breaks The fracture line is transverse and displacement is slight (or else there must be a fracture-dislocation—*see* page 297).

CLOSED TREATMENT

REDUCE — Displacement is slight and reduction may not be necessary

HOLD — A complete plaster is applied, to include the elbow and wrist joints, exactly as

of the body imposes a supination force and the lower radius, with the hand, is twisted and tilted backwards and radially.

SIGNS

LOOK — The normal slight concavity on the back of the wrist is obliterated, and a depression is seen in front of the lower radius; this dinner-fork deformity may be obscured by swelling.

FEEL — The bony displacement may be palpated, and tenderness elicited.

MOVE — Wrist movements are limited and painful.

X-RAY — A transverse fracture of the radius is seen less than one inch from the wrist, and often the ulnar styloid process is fractured. The radial fragment may be (*a*) shifted and tilted backwards; (*b*) shifted and tilted radially; and (*c*) impacted.

Sometimes the radial fragment is comminuted on its posterior aspect, and occasionally it is broken in two pieces.

TREATMENT

REDUCE — Under anaesthesia the fracture is reduced in 3 stages.

(1) *Disimpaction* — Disimpaction may be achieved by pulling on the hand. If this fails, the backward tilt should be temporarily increased and then traction resumed.

(2) *Pronation* — The patient's wrist is palmarflexed and the forearm strongly pronated (the force is applied in the reverse direction to that which caused the fracture).

(3) *Pressure* — To ensure that reduction is complete, the surgeon presses the lower radius firmly forwards and towards the ulna.

HOLD — While the forearm is still held pronated and the wrist slightly palmarflexed, a plaster slab is applied. It extends from just below the elbow to the metacarpal necks and two-thirds of the way round the circumference of the wrist. It is held in position by a crêpe bandage. While the plaster slab is setting the surgeon holds the reduction by firm pressure with his thenar eminences.

Following reduction x-rays are essential; they should be repeated after 7 days, for redisplacement is common. Sometimes it is necessary to split the crêpe bandage on the day following reduction; there should be no delay or hesitation in splitting the bandage if the fingers are swollen, cyanosed or painful.

The fracture unites in 6 weeks and, even in the absence of radiological proof of union, the slab may safely be discarded and replaced by a temporary crêpe bandage.

EXERCISE — The patient should not be allowed to leave hospital until she can comb her hair and move her fingers fully. Regular active exercises of the shoulder and fingers must be insisted upon — they are more important than treatment of the fracture.

When the plaster has been removed, return of wrist and radio-ulnar movements is encouraged by the regular practice of such normal activities as washing up.

COMPLICATIONS

MAL-UNION — Mal-union is common, either because reduction was not complete or because displacement within the plaster was overlooked. The appearance is ugly, and weakness and loss of rotation may persist. In most cases vigorous exercises and physiotherapy are the only treatment needed or advisable. Where the disability is severe

delayed splintage method is employed, the application of a complete plaster being postponed until movements have been regained.

COMPLICATIONS

MAL-UNION — Mal-union of the ulna causes little disability but, unless the ulna has been perfectly reduced, the radial head remains dislocated and limits elbow flexion. In children no treatment is advised. In adults excision of the head of the radius may be needed.

NON-UNION — Non-union of the ulna should be treated by bone grafting. If the radial head is dislocated it should first be excised.

DISLOCATION OF RADIAL HEAD

Dislocation of the radial head may occur in a pronation injury without fracture of the ulna. The dislocation is reduced by supination and direct pressure, and the arm held supine in plaster for 6 weeks. Dislocation of the radial head may be congenital and is then sometimes bilateral.

FRACTURE-DISLOCATION: (B) LOWER (GALEAZZI)

MECHANISM

The usual cause is a fall on the hand; almost certainly a rotation force is superimposed. The radius fractures in its lower third and the inferior radio-ulnar joint dislocates. The injury is an almost exact counterpart of the Monteggia fracture-dislocation

SIGNS

LOOK — The lower ulna is obviously dislocated.

FEEL — It is important to test for an ulnar nerve lesion, which is common.

MOVE — Movement should not be attempted.

X-RAY — A transverse or short oblique fracture is seen in the lower third of the radius, with angulation. The inferior radio-ulnar joint is dislocated.

TREATMENT

As with the Monteggia fracture-dislocation, closed reduction is sometimes successful and can be held by a full above-elbow plaster which must be maintained for at least 3 months. It is probably better, however, to reduce and plate the radius at open operation. Accurate reduction of the radius ensures replacement of the radio-ulnar dislocation.

THE WRIST

COLLES' FRACTURE

MECHANISM

This injury, which is much the commonest of all fractures, is probably due to a supination force. The patient, often an elderly woman, falls on the dorsiflexed hand, breaking the radius transversely just above the wrist. Probably the momentum

strikes an object. Forward displacement is greater, however, and several metacarpal bones may also be fractured. Treatment is similar.

(c) In children, the lower radial epiphysis may displace forwards (the common backward displacement is described on page 300). Forward displacement is reduced by dorsiflexion and the reduction is held by a below-elbow plaster for 6 weeks.

LORRY DRIVER'S FRACTURE

This injury, sometimes called a fractured radial styloid, is caused by a forced radial deviation of the wrist and may follow a fall, but is commoner when the starting handle of a lorry "kicks back". The fracture line is transverse, extending laterally from the articular surface of the radius. The fragment, which is much more than the radial styloid process, is often undisplaced.

If there is displacement it is reduced by strong traction and ulnar deviation. The wrist is held in ulnar deviation by a plaster slab round the outer forearm extending from below the elbow to the metacarpal necks. Imperfect reduction may lead to osteoarthritis. If closed reduction is imperfect the fracture should be reduced openly, and, if it is then transfixed with a screw, plaster is unnecessary.

FRACTURED CARPAL SCAPHOID

MECHANISM

A fall on the dorsiflexed hand may fracture the carpal scaphoid bone. Probably the force is a combination of dorsiflexion and radial deviation. The deviation occurs between the two rows of carpal bones; the scaphoid, lying partly in each row, fractures across its waist.

SIGNS

LOOK — The appearance is usually normal.

FEEL — There is localized tenderness in the [illegible]

MOVE — [illegible]

X-RAY — [illegible] ential; often a recent fracture shows only in the oblique view. Usually the fracture line is transverse, and through the narrowest part of the bone (waist), but it may be more proximally situated (proximal pole fracture). Sometimes only the tubercle of the scaphoid is fractured. There is rarely much displacement.

DIAGNOSIS

A fall on the dorsiflexed hand may sprain the wrist or fracture the scaphoid bone. But sprains are rare and must not be diagnosed unless repeated x-rays have excluded a fracture. Immediately after injury the fracture line may be almost invisible; where there is the slightest doubt, further x-rays must be taken at 10 days after injury, when the fracture can be clearly seen.

and the patient relatively young, the lower inch of the ulna may be excised to restore rotation and the radial deformity corrected by osteotomy.

DELAYED UNION AND NON-UNION — Delayed union and non-union of the radius do not occur, but the ulnar styloid process often joins by fibrous tissue only and remains painful and tender for several months.

STIFFNESS — Stiffness of the shoulder is due to neglect, yet it is probably the commonest complication. Finger stiffness can nearly always be avoided by active use but, very rarely, Sudeck's atrophy develops and stiffness persists for a period of months.

NERVE INJURY — Nerve injury is rare, and even median compression in the carpal tunnel is surprisingly uncommon.

TENDON INJURY — Tendon injury (delayed rupture of the long thumb extensor tendon) rarely occurs after a Colles' fracture. It is less rare after an apparently trivial and undisplaced crush of the back of the lower end of the radius (*see* page 142).

OTHER FRACTURES OF LOWER RADIUS

JUVENILE COLLES' FRACTURE

The force which in an older person causes a Colles' fracture may, in a child, cause a fracture-separation of the lower radial epiphysis. The epiphysis is shifted and tilted backwards and may also be shifted and tilted radially. As it displaces it carries with it a triangular fragment of the radial metaphysis. The fracture is reduced and held in the same way as a Colles' fracture.

Fracture-separation of the lower radial epiphysis does not interfere with growth of the bone; but a minor crush of the radial epiphysis without displacement may do so, and premature epiphyseal fusion then occurs. The ulna outgrows the radius and the ulnar head dislocates. It may subsequently be necessary to excise the lower inch of the ulna.

FRACTURES WITH FORWARD DISPLACEMENT

The terms "reversed Colles' fracture" and "Smith's fracture" are somewhat misleading. The following varieties of fractured lower radius with forward displacement occur.

(*a*) The commonest variety is an oblique fracture extending from the wrist joint obliquely upwards and forwards. The separated anterior fragment of the radius shifts proximally, carrying the hand with it. This injury, occurring mainly in men, is probably due to forced pronation

The fracture is reduced by strong traction and supination. Reduction is unstable and the fracture can be held reduced only in an above-elbow plaster with the forearm fully supinated for at least 6 weeks.

(*b*) A true reversed Colles' fracture (a transverse fracture of the lower radius with forward shift and tilt) is very rare, and occurs mainly in elderly women. It is reduced by disimpaction and held dorsiflexed, preferably in supination and in an above-elbow plaster, for 6 weeks.

A similar fracture sometimes occurs in motorcyclists if the hand on the handlebars

sprains is treatment indicated. With established non-union splintage and grafting are useless. Excision of the radial styloid process may postpone the development of osteoarthritis and often restores excellent function. Alternatively the radial styloid process may be osteotomized, slid a quarter of an inch proximally and reattached to the radius with a screw.

OSTEOARTHRITIS — Osteoarthritis of the wrist may be a sequel to non-union of the scaphoid bone, especially when there has been avascular necrosis. The patient complains of repeated sprains and later of weakness, stiffness and pain. If a wrist strap or polythene splint fails to relieve symptoms, the wrist should be arthrodesed (*see* page 103). Sometimes the predominant symptoms in osteoarthritis are those of median nerve compression, when simple division of the anterior carpal ligament may be the only treatment necessary.

INJURIES OF OTHER CARPAL BONES

FRACTURED TRIQUETRAL BONE

As the result of a fall, a flake of bone may split off the back of the triquetral bone. The wrist is swollen, tender, and painful on movement. The injury is treated as a sprain, with a temporary crêpe bandage and active exercises. Full recovery occurs, but the wrist may remain painful for many weeks. (A fracture of the scaphoid tubercle may also be treated as a sprain and the fracture disregarded.)

KIENBÖCK'S DISEASE

Kienböck's disease (aseptic necrosis of the semilunar bone) is probably due to injury. Months or years after slight or repeated minor injury, the wrist becomes painful and stiffish. The third knuckle recedes slightly and is painful on percussion. The semilunar bone is tender and wrist movements, especially dorsiflexion, are restricted and painful. X-rays show increased density and sometimes fragmentation of the bone, and later osteoarthritis of the wrist. In mild cases a polythene splint is worn for three or more months. Later or severe cases may require arthrodesis of the wrist.

SEMILUNAR AND PERILUNAR DISLOCATIONS

MECHANISM

A fall on the dorsiflexed hand may displace the hand and most of the carpus backwards, leaving only the semilunar bone in contact with the radius (perilunar dislocation). Usually the hand immediately snaps forwards again but, as it does so, the semilunar bone is levered forwards out of position (semilunar dislocation). A semilunar dislocation can possibly occur without preceding perilunar dislocation; during forced dorsiflexion the bone might conceivably be ejected like an orange pip.

If the dorsiflexion injury has also fractured the scaphoid, its proximal half remains alongside the semilunar bone in whatever position that bone lies.

SIGNS

LOOK — The displacement is obscured by swelling of the wrist.

FEEL — It is important to test for diminished sensation in the distribution of the median nerve, which is usually compressed.

MOVE — The wrist is immobile. The patient can move his fingers only with difficulty because the tendons, like the median nerve, are compressed in the carpal tunnel.

TREATMENT

REDUCE — Usually reduction is unnecessary because displacement is rare. Nevertheless, anaesthesia is sometimes an advantage to enable a well fitting plaster to be applied.

HOLD — A complete plaster is applied from the upper forearm to just short of the metacarpophalangeal joints of the fingers, but incorporating the proximal phalanx of the thumb. The wrist is held dorsiflexed and the thumb forwards in the "glass-holding" position. The plaster must be carefully moulded into the hollow of the hand. It is retained (and if necessary renewed) for at least 3 months. It is then taken off and the wrist x-rayed in all three positions. The films may show one of the following appearances.

Union in all three views — This is rarely convincing but, if it seems likely, the plaster should be replaced by a cock-up splint and the wrist re-examined and x-rayed again in 2 weeks' time. If there is then no tenderness, and the x-ray appearance is satisfactory, the splint is discarded but the wrist is re-examined after a further 2 weeks. Should doubt still remain, the fracture is treated as in the next example.

Fracture line still obvious — A fresh plaster is applied as for the original fracture. After a further 3 months the wrist is re-examined and, if there is still no evidence of union, a further period in plaster may be advisable, for it is said that every recent fractured scaphoid waist will unite in less than 1 year if completely immobilized. If, however, after 3–6 months in plaster the fracture line appears unduly wide ("cavitation") bone grafting is probably indicated (Amstrong).

Proximal fragment too dense — The proximal fragment may die, especially in proximal pole fractures, and then appears too dense. Although revascularization and union are theoretically possible, they take a period of years. The dead fragment and the radial styloid process should therefore be excised forthwith. (Some surgeons excise both scaphoid fragments or even the entire proximal row of the carpus, but these measures are probably unnecessary)

EXERCISE — Shoulder movements are practised from the start, and the plaster is so designed that function of the hand is limited as little as possible. Wrist movements are regained when the plaster is removed.

COMPLICATIONS

DELAYED UNION — Even without evidence of union 3 months after the injury, treatment in plaster should be persevered with, providing the proximal fragment is not dense.

EARLY NON-UNION — It may be apparent in 3–6 months that the bone ends at the fracture are becoming sclerosed. Through a hole drilled across the fracture, a bone graft is inserted like a dowel and plaster is then worn for at least 3 months. Grafting is not advised if more than 1 year has elapsed after the fracture.

ESTABLISHED NON-UNION — A patient may be seen because of a recent injury, but x-rays show an old, un-united fracture with sclerosed edges. He may recall a previous "sprain" which was in reality an undiagnosed scaphoid fracture. The wrist soon became painless, confirming both patient and doctor in their error.

Providing avascular necrosis has not occurred, non-union of the scaphoid does not necessarily cause symptoms. Only if the patient complains of weakness or repeated

almost invariably unite and even if angulation persists, malunion is less disabling than stiffness.

The guiding principles of treatment are as follows:

SWELLING — Swelling must be controlled by elevating the hand and by early and repeated active exercises.

SPLINTAGE — Splintage must be kept to a minimum. The best splint (if splintage is essential) is a narrow garter attaching the finger to its neighbour so that both move as one. Apart from this, only the injured finger should be splinted and that only in the functional position (partial flexion). The thumb may sometimes be splinted straight because, even if it becomes stiff in that position, it remains useful. Sometimes an external splint, to be effective, would need to immobilize other fingers; if so it is preferable to use internal splintage with Kirschner wires, a method advocated by Furlong, to whose account of hand injuries acknowledgement is made.

SKIN DAMAGE — Skin damage demands wound excision followed by suture or skin grafting. If the wound is compound, treatment of the skin takes precedence over treatment of the fracture. (Open injuries of the hand are described on page 148.)

FRACTURES

BASE OF THUMB METACARPAL

An unskilled boxer may, while punching, sustain a fracture of the first metacarpal base. Localized swelling and tenderness are found, and x-ray shows a transverse fracture a quarter of an inch distal to the carpometacarpal joint, with outward bowing and usually impaction.

TREATMENT

To reduce the fracture, the surgeon pulls on the abducted thumb and, by levering the metacarpal outwards against his own thumb, corrects the bowing. A firm crêpe bandage usually suffices to prevent redisplacement, but if the fracture feels unstable a plaster slab is applied, extending from the forearm to just short of the interphalangeal thumb joint; the thumb is in the position of function where the index finger can make pulp-to-pulp contact with it. The slab is removed after 3 weeks and movement usually recovers rapidly.

BENNETT'S FRACTURE-DISLOCATION

This fracture, too, occurs at the base of the first metacarpal bone and is commonly due to punching; but the fracture is oblique, extends into the carpometacarpal joint and is unstable. The thumb looks short and the carpometacarpal region swollen. X-rays show that a small triangular fragment has remained in contact with the medial half of the trapezium, while the remainder of the thumb has subluxated proximally.

TREATMENT

There are three alternative methods of treatment.

ORTHODOX TREATMENT (CONTINUOUS TRACTION) — A "Tom Thumb" splint is used; this term implies that a tiny Thomas splint is used to maintain traction on the thumb. A

X-RAY — In the anteroposterior view, the semilunar bone has lost its normal somewhat quadrilateral shape. It resembles instead a segment of a circle with sides converging like radii towards the pointed distal end. The scaphoid may also have fractured.

In the lateral view it is easy to see that dislocation has occurred between the semilunar bone and the os magnum. A dislocated semilunar bone is grossly tilted forwards and is displaced in front of the radius, while the os magnum and metacarpal bones are in line with the radius. With a perilunar dislocation the semilunar is only tilted forwards slightly and is not displaced forwards, and the os magnum and metacarpals lie behind the line of the radius.

TREATMENT

REDUCE — The surgeon pulls strongly on the dorsiflexed hand. While maintaining traction he slowly palmarflexes the wrist, at the same time squeezing the semilunar bone backwards with his other thumb. These manœuvres usually effect reduction; they also prevent conversion of perilunar to semilunar dislocation. Reduction is imperative and if closed reduction fails, the bone is exposed by an anterior approach which has the advantage of decompressing the carpal tunnel. While an assistant pulls on the hand, the semilunar bone is levered into place. If at operation the bone is seen to be totally detached, some surgeons advise its immediate excision, because avascular necrosis is inevitable, but excision leaves some weakness and stiffness of the wrist.

HOLD — Reduction is stable, but a plaster slab holding the wrist neutral is comforting, and is worn for 3 weeks.

EXERCISE — Finger movements are begun at once and wrist movements regained when the slab is removed.

COMPLICATIONS

NERVE INJURY — Median nerve compression in the carpal tunnel occurs almost invariably, but usually recovers after reduction.

UNREDUCED DISLOCATION — This is not uncommon and presents as a painful stiffish wrist, with median paraesthesia. The semilunar bone should be excised through an anterior incision. Some surgeons prefer to excise the entire proximal row of bones.

FRACTURED SCAPHOID — It is important always to exclude a scaphoid fracture by x-ray after reduction of the dislocation (which will automatically have reduced the fractured scaphoid). Following reduction, an anterior plaster slab is applied but, after one week, it is replaced by a full scaphoid plaster and the injury is then treated as a fractured scaphoid.

AVASCULAR NECROSIS — The semilunar and the proximal half of the scaphoid may become avascular. Revascularization sometimes follows prolonged splintage. If the dead bones have been allowed to crush, osteoarthritis is likely to develop.

THE HAND

MANAGEMENT

In the hand, even more than elsewhere, function is a vital consideration. Fingers stiffen easily and a stiff finger is often worse than no finger. Fractures in the hand

Considerable displacement is reduced by direct pressure between the surgeon's finger on the metacarpal head and his thumb on the fracture. The reduction can be held by a plaster slab extending from the wrist to the finger nail, holding the joints flexed. If, however, the reduction feels stable, plaster is unnecessary. A small felt pad is placed over the palmar aspect of the metacarpal head and another over the dorsum of the fracture. These are held on with a crêpe bandage and movements are encouraged (Furlong).

PROXIMAL PHALANX

Fracture of a proximal phalanx is usually the result of direct violence, and may be compound. The phalanx fractures transversely, often with forward angulation which may damage the flexor tendon sheath. Any finger may be affected.

TREATMENT

The fracture is reduced by pulling on the bent finger and thumbing the phalanx straight. A flexed position must be maintained to hold the reduction, and is most simply achieved by placing a rolled bandage in the palm and holding the flexed finger over it with a crêpe bandage. To prevent rotation deformity, the flexed finger must point towards the scaphoid bone. (An alternative method is to suture the finger pulp to the skin of the thenar eminence.) After 3 weeks the bandage or suture may be removed and a posterior plaster slab applied, holding the finger in the same position; the slab is taken off several times a day and the patient exercises the finger while he protects the fracture with his other hand.

FRACTURES INTO JOINTS

Any finger joint may be injured by a direct blow (often the overlying skin is damaged), or by an angulation force, or by the straight finger being forcibly stubbed. The affected joint is swollen, tender and too painful to move. X-rays may show that a fragment of bone has been sheared off or avulsed.

TREATMENT

It is usually best to disregard the fracture, to anchor the finger to its neighbour with a garter, and to concentrate on regaining movement.

If a bone fragment is grossly displaced, recovery of function may be hastened by its removal.

Note—The terminal phalanx may be struck by a hammer, or caught in a door, and the bone shattered. The fracture is disregarded and treatment is focused on controlling swelling and regaining movement.

DISLOCATIONS

CARPOMETACARPAL

The thumb is most frequently affected and clinically the injury then resembles a Bennett's fracture-dislocation; but x-rays show proximal subluxation of the first metacarpal bone without a fracture. Any or all of the other metacarpal bones may be dislocated, usually backwards, but sometimes sideways.

strong wire splint of this shape is fashioned, incorporated in a plaster, and the thumb is attached to it by skin traction with collodion gauze. The plaster extends from the forearm to the knuckles, and holds the thumb in the position of function. The splint is maintained for 3 weeks. Unless x-rays show that perfect reduction is being maintained, the method should be quickly abandoned.

FUNCTIONAL TREATMENT — If the fracture is disregarded and active use encouraged, painless function is quickly regained. The fracture unites but in faulty position. It is widely supposed that osteoarthritis is an inevitable sequel to this method, but there is little supporting evidence for this belief.

OPERATIVE TREATMENT (INTERNAL FIXATION) — The fracture is held reduced by manual traction while short lengths of Kirschner wire are driven obliquely through the metacarpal base (by-passing the small fragment) into the carpus. Their protruding ends are cut short and incorporated in a small plaster slab. After three weeks the slab is removed and the wires pulled out; movement is quickly regained.

METACARPAL SHAFTS

A direct blow may fracture one or several metacarpal shafts transversely. Transverse fractures may be compound. A twisting or punching force may cause a spiral fracture of one or more shafts. There is local pain and swelling, sometimes deformity, and one knuckle may have receded.

TREATMENT

If the fracture is compound, the wound must be excised and the skin sutured or grafted.

Spiral fractures or transverse fractures with slight displacement require no reduction. A garter attaches the finger of the injured metacarpal bone to its neighbour, and active movements are encouraged. The garter not only permits early movement but effectively prevents rotation deformity. The fracture unites in 3 weeks and the garter is then discarded.

Transverse fractures with considerable displacement (backward angulation) are reduced by traction and pressure. Reduction can easily be held by a plaster slab extending from the forearm over the flexed fingers (only the undamaged ones). The slab is maintained for 3 weeks and the undamaged fingers exercised. A more elegant method, if asepsis can be assured, is to insert a short length of Kirschner wire across the fracture through a dorsal incision. If several metacarpal bones are fractured, only alternate ones need fixation. No external splint is necessary and early movements are possible.

METACARPAL NECKS

A blow with the fist may fracture the metacarpal neck of the fifth finger or occasionally of the index finger. A lump is visible and x-rays show a transverse fracture with backward angulation and sometimes impaction.

TREATMENT

Slight displacement may be disregarded and the patient is encouraged to use his hand; a small lump may remain, but full function is rapidly regained.

CHAPTER 23

INJURIES OF THE SPINE AND PELVIS

CERVICAL SPINE

WHEN cervical spine injury is complicated by paraplegia, spinal cord damage is more important than the fracture. A high cervical fracture may prove fatal as the result of cord transection. It is estimated that some 10 per cent of the patients who survive severe neck injuries have some degree of paraplegia; in the remainder, the cord is undamaged.

The problem of traumatic paraplegia is considered on page 316.

ATLAS AND AXIS

MECHANISM

A compression force while the neck is extended (for example, a fall on the head) may split the atlas, separating its anterior or posterior arch. A fracture of the base of the odontoid process, or rupture of the ligament which holds the odontoid process in place, may occur in road accidents, probably as the result of a combined flexion and rotation force.

SIGNS

LOOK — The patient supports his head with his hands "in case it falls off". With axis fractures the neck may be twisted or tilted.

FEEL — Palpation is of no value.

MOVE — The patient will not and cannot nod or shake his head, nor should he be asked to try

X-RAY — An antero-posterior view taken through the open mouth mav show a fractured [illegible] teral view, if the [illegible] all be displaced [illegible] only the skull and atlas are displaced forwards

SPONTANEOUS DISLOCATION — "Spontaneous" forward dislocation of the atlas may be associated with ligamentous laxity due to neighbouring *infection (for example, throat* infection). It may be due to trivial or unnoticed injury or sudden movement.

TREATMENT

REDUCE — Displacement is best corrected *without anaesthesia. The patient lies supine* with his head projecting beyond *the edge of the table, supported by the hands of the* seated surgeon. The surgeon *gently* extends *the neck, then corrects any twist or tilt*

TREATMENT

In the thumb, the dislocation is easily reduced by traction, but reduction is unstable and can be held only by one of the methods used for a Bennett's fracture-dislocation, namely, skin traction and a "Tom Thumb" splint, or Kirschner wires driven through the metacarpus into the carpus. Splintage is discontinued after 3 weeks.

Dislocations at the other carpometacarpal joints are easily reduced by traction and pressure. Reduction is stable and only a crêpe bandage is necessary.

METACARPOPHALANGEAL

Usually the thumb is affected, sometimes the fifth finger, and rarely the other fingers. A hyperextension force may dislocate the phalanx backwards, and the capsule and muscle insertions in front of the joint may be torn. If the metacarpal head has been forced like a button through the hole, closed reduction may be impossible.

TREATMENT

Closed reduction is first attempted by pulling on the thumb and levering the phalanx forwards. If this fails, the joint is exposed from behind and, while strong traction is applied, the metacarpal head is levered into place. The joint is then strapped in the flexed position for 1 week.

INTERPHALANGEAL

Backward dislocation at the distal joint is common and is easily reduced by pulling. The joint may be strapped flexed for a few days.

SPRAINS

Sprains of the finger joints are common, and usually due to an angulation force. Sometimes a small bony fragment is avulsed.

The injured finger should be splinted to its neighbour by means of a garter and active movements encouraged but not forced. The patient must be warned that, following a sprain, the joint is likely to remain swollen, slightly painful and stiffish for 6–12 months.

Sprains of the metacarpophalangeal joint of the thumb may behave like sprains of other finger joints; sometimes, however, a complete ligamentous rupture occurs. It is therefore wise to treat any sprain of this joint by strapping in the flexed position for at least 3 weeks; otherwise the surgeon is likely to be blamed for recurrent subluxation.

Suggestions for further reading

Adams, J. C (1948). "Recurrent Dislocation of the Shoulder" *J. Bone Jt Surg.*, 30B, 26

Evans, E. M. (1949) "Pronation Injuries of the Forearm." *J. Bone Jt Surg*, 31B, 578.

— (1951) "Fractures of the Radius and Ulna." *Ibid.*, 33B, 548.

Furlong, R. (1957) *Injuries of the Hand* London; Churchill.

McLeane, M. and Merson, R D (1954) "Injuries of the Lateral Condyle Epiphysis of the Humerus in Children." *J. Bone Jt Surg.*, 36B, 84.

Osmond-Clarke, H. (1948) "Habitual Dislocation of the Shoulder." *J. Bone Jt Surg.*, 30B, 19

Wagner, C J. (1956). "Perilunar Dislocations." *J Bone Jt Surg*, 38A, 1198.

vertex, using Crutchfield's tongs, or through bore holes above each zygoma using Blackburn's caliper. Only local anaesthesia is necessary.

A weight of 20 pounds is applied with the neck slightly flexed, and the head of the bed is elevated. After 20 minutes a lateral film is taken and, if this indicates that malalignment has been corrected, the neck is slightly extended and the weight reduced to 10 pounds. If malalignment has persisted the pull is not reduced but is increased, and a further film taken 20 minutes later; further increases in weight and further films are taken at 20-minute intervals until alignment has been corrected.

HOLD — Once the fracture has been reduced, light traction (10 pounds) with the neck slightly extended should be maintained for 2 weeks. Then plaster may be applied as already described, but it is probably wiser to use internal fixation instead. The spinous processes of the damaged vertebrae are exposed, bone grafts laid alongside them, and the spinous processes fixed together with wire. Only when the wire has been firmly fixed is the traction removed. A neck brace or polythene collar is worn for at least 3 months.

OTHER CERVICAL SPINE INJURIES

FRACTURED SPINOUS PROCESS (CLAY-SHOVELLER'S FRACTURE)

Occasionally the seventh cervical or first thoracic spinous process is avulsed by uncoordinated muscle action, as when unloading a pitchfork or shovel. Considerable pain and local tenderness occur, and x-rays show the affected spinous process to be completely separated. The only treatment necessary is to avoid repeating the movement which caused the injury. Occasionally pain persists, and excision of the avulsed portion of bone is then advisable.

EXTENSION INJURY

A relatively minor fall on the forehead may hyperextend the neck. The patient is aged over 40 years and has a tell-tale bruise on the forehead. The bone is undamaged but the cord may be damaged if the neck had limited movement. Neck movements are limited in all directions and x-rays show cervical spondylosis. Those unfamiliar with the condition are surprised that the relatively minor neck signs should be associated with partial paraplegia. The paraplegia will need treatment (*see* page 316) but decompression is not advised, and there is no fracture to need reduction. A cardboard and felt collar should be worn for 3 weeks.

THORACOLUMBAR SPINE

The spine is particularly vulnerable to injury where the flexible lumbar portion joins the relatively fixed thoracic and sacral portions. The lumbosacral junction is susceptible to lifting strains which may damage ligaments and permit disc prolapse (*see* page 178). Crush injuries are liable to damage the thoracolumbar junction. A twisting force may damage any part of the lumbar spine.

MANAGEMENT

The management of a patient with suspected fracture of the spine is conducted in three stages:

held in plaster

HOLD — Even an undisplaced fracture must be held in plaster. The plaster extends from the forehead over the head and well down the chest and shoulders, so that no neck movement, and only sufficient jaw movement to permit eating, is possible. The plaster is worn for 3 months. The patient is allowed up as soon as he feels comfortable.

EXERCISE — No special exercises are necessary and movements return when the plaster is removed.

COMPLICATIONS

If a fractured odontoid process joins only by fibrous tissue, subsequent displacement may occur, causing a late paraplegia. The displacement should be reduced at operation and stabilized by means of bone grafts extending from the occiput to the upper cervical vertebrae.

FRACTURES AND DISLOCATIONS BELOW THE AXIS

MECHANISM

The usual cause is a hyperflexion injury, as by a fall on the head or diving into shallow water. The result may be a fracture, a fracture-dislocation, or a dislocation with no fracture which sometimes reduces itself spontaneously.

SIGNS

The neck signs are as follows.

LOOK — The head is held still, possibly in a twisted or tilted position.

FEEL — Palpation is of no value

MOVE — Movements are limited and painful, but it is best not to attempt them until x-ray films have been seen.

X-RAY — A lateral view is the most useful and may show (*a*) crushing of the front of one vertebral body (this is uncommon), (*b*) forward shift of one vertebral body on the body below, sometimes with fractured facets (this usually occurs in the lower two or three vertebrae), or (*c*) no abnormality, in which case a temporary forward dislocation may have occurred, but the damage is revealed only by repeating the x-ray with the head bent forwards; the film may then show forward shift of one body and subluxation or dislocation of the articular facets.

CLOSED TREATMENT

REDUCE — An injury without complete dislocation of the facets can as a rule be reduced by extending the patient's head over the edge of a table on which he is lying supine.

HOLD — Plaster is applied, holding the neck in the extended position, and is retained for 3 months. A removable collar is worn for a further 3 months to protect the neck against sudden unguarded movements.

EXERCISE — No exercises need be done

OPERATIVE TREATMENT

REDUCE — Skull traction should be employed if (*a*) dislocation cannot be reduced by simple manipulation, or (*b*) there is paraplegia. The traction may be applied near the

Examples are a fall from a height (ladder workers), a roof-fall (miners), an upward thrust (when a ship hits a mine), or a crash landing in an aircraft.

A slight injury may cause a pathological fracture in bone which is osteoporotic or the seat of malignant disease. Nearly all pathological fractures of vertebrae are of the stable crush variety.

SIGNS

LOOK — A slight kyphos may be visible.

FEEL — The kyphos can sometimes be felt and there is local tenderness. No gap is palpable between the spinous processes.

MOVE — Back movements should not be tested. Movements of the legs are normal and there is no paraplegia.

X-RAY — In the antero-posterior view, one vertebral body is slightly crushed but neither shifted nor rotated. The laminae, facets and processes are intact. In the lateral view one vertebral body is wedged forwards, though not grossly, and its upper border is fractured. There is no forward shift of one vertebral body on another. The pedicles are intact and in their correct position, and the spinous processes are not widely separated.

ORTHODOX METHOD OF TREATMENT

REDUCE — The fracture can be rapidly and completely reduced by hyperextension without anaesthesia The prone patient is stretched between two tables, with the symphysis pubis and manubrium sterni clear of them (Watson-Jones' method).

HOLD — A plaster jacket reaching from the symphysis pubis to the manubrium sterni is applied in the hyperextended position. Plaster is retained for 3 months. The patient may get up after 2 weeks and lead an active life.

EXERCISE — The back muscles should be actively exercised within the plaster and movements restored when the plaster is removed.

FUNCTIONAL METHOD OF TREATMENT

The fracture is disregarded and only the soft tissues treated. The patient is put to bed with a lumbar pillow. After about 3 days he turns onto his face, is given radiant heat for comfort, and is taught extension exercises. Within 3 weeks he gets up, practises exercises still more vigorously, and may begin sedentary work. Usually he can resume light manual work by 6 weeks, and heavy work in 12 weeks.

The functional method may only be used if the fracture is without doubt stable. Should there be doubt, the orthodox treatment must be employed. The reasons which have led to the employment of the functional method in many orthopaedic centres are as follows.

(*a*) Even after prolonged hyperextension in plaster, many crush fractures re-wedge. Nicoll has shown that re-wedging is inevitable if the intervertebral disc is damaged at the time of injury. (*b*) Wedging of moderate degree does *not impair function*, providing full back movements have been regained. (*c*) The results following the functional method are superior to those of the orthodox treatment. Thus, among miners only one in four returned to full work at the coal face after treatment in plaster, whereas twice this number returned after the functional method of treatment (Nicoll). It is suggested that

(1) At the scene of the accident it should be assumed that the injury is serious. The patient must not be allowed to flex his spine. He is lifted and transported only with the spine extended and, ideally, in the prone position.

(2) On admission to hospital, the patient must be examined for associated injuries which may require urgent treatment.

(3) Finally, the fracture itself must be assessed and treated.

SYMPTOMS

The nature of the accident may suggest the diagnosis, and the distribution of pain may indicate the level of injury. It is of greater importance to enquire if there are symptoms suggestive of visceral damage. If the injury was slight the fracture may have been pathological and there may be a history of malignant disease.

GENERAL SIGNS

The patient may be shocked. The age and general condition may suggest that the fracture is pathological in nature. It is essential always to examine the entire patient, to determine whether there has been associated injury of the skull, chest, abdomen or limbs.

The lower limbs must be examined for evidence of cord or nerve root damage.

LOCAL SIGNS

Clinical examination of the back should not be carried out unless, without producing pain, the patient can be gently rolled onto his side.

LOOK — A kyphos may be seen.

FEEL — The spinous processes and intervening ligaments are palpated.

MOVE — Movement should not be attempted

X-RAY — Antero-posterior and lateral films are taken but, because the patient must be disturbed as little as possible, films of less than first-class quality should be accepted.

Systematic examination of the x-ray film facilitates classification and description of the fractures. Formerly, vertebral fractures were divided into those of the bodies, laminae, pedicles, facets and processes. The modern classification into "stable" and "unstable" fractures is of much greater value.

Stable fractures — The vertebral bodies are neither grossly crushed, nor shifted one upon the other, nor rotated, the neural arch is intact, the facets are in their correct position, and the spinous processes not too widely separated. In a stable fracture the supraspinous and interspinous ligaments are intact; the cord is undamaged and is in no danger.

Unstable fractures — A vertebral body may be severely crushed, or shifted out of position, or rotated; the neural arch may be fractured, the facets displaced or fractured and the spinous processes may be too widely separated. If any of these features is present, the supraspinous and interspinous ligaments have ruptured and the fracture is unstable. The cord may be damaged, but even if it is intact there is risk of damage on movement.

STABLE CRUSH FRACTURES

MECHANISM

A stable crush fracture (anterior wedge fracture) is the commonest spinal fracture. It is due to a compression or hyperflexion force or to a combination of both.

traumatic spondylolisthesis is suspected if the injury was severe and the fracture line appears irregular on x-ray.

An attempt may be made at closed reduction by slinging the pelvis from a beam and, if reduction has been achieved, it is maintained by a plaster incorporating the trunk and both hips (Watson-Jones). The plaster is retained for 6 months. Alternatively, the fracture is exposed, reduced, and fixed internally by bone grafts and screws.

UNSTABLE FRACTURES AND FRACTURE-DISLOCATIONS WITHOUT PARAPLEGIA

MECHANISM

Unstable fractures and fracture-dislocations can be caused by a variety of forces which may be combined in various ways:

(*a*) Severe compression or hyperflexion may cause gross comminution of a vertebra, with ruptured interspinous ligaments. Very rarely the facets of the vertebra immediately above the damaged one have leap-frogged forwards over those of the crushed vertebra and are locked in that position.

(*b*) A twisting force may tear ligaments and fracture pedicles or facets. One vertebra is squashed and often rotated or even displaced laterally.

(*c*) A shearing force may tear the ligaments, fracture the pedicles or facets, and then displace the vertebral column forwards, taking with it a slice off the top of the vertebra below.

The compression type of injury rarely causes paraplegia; the other types often do so. The important point however is that, even if the cord originally escapes damage, it may be damaged by further displacement unless movement is prevented.

SIGNS

The signs and treatment of traumatic paraplegia are described later. In this section only unstable fractures without paraplegia are considered.

LOOK — A kyphos may be visible.

FEEL — If a gap can be felt between two adjacent spinous processes the fracture is unstable. Complete clinical examination should not be carried out unless the patient can be turned gently onto his side without much discomfort, and is often postponed until x-ray films have been taken.

MOVE — Movements should not be attempted.

X-RAY — In the antero-posterior view, one vertebra may appear squashed, rotated, or shifted laterally, and fractured facets, pedicles, or transverse processes may be seen.

The lateral view may show one vertebra grossly crushed, or shifted forwards with a slice off the body below, a fracture or displacement of pedicles or facets and spinous processes too widely separated.

CLOSED TREATMENT

Further displacement of the spine must, at all costs, be prevented.

REDUCE — The spine is gently extended, but not hyperextended.

with hyperextension in plaster, torn muscles are splinted in their shortened position, resulting in adhesions.

OTHER STABLE FRACTURES

LATERAL WEDGE FRACTURE

Because this is caused by a combined flexion and twisting injury it is rare, except in miners who often work lying on one side.

After injury, an abdominal emergency may be simulated because, in addition to back pain, abdominal pain, tenderness and rigidity often occur. Antero-posterior x-ray shows the spine to be angulated, a vertebral body crushed on one side, and a transverse process fractured on the opposite side. The fracture is stable, in that the cord is undamaged and displacement will not increase, but one or two nerve roots may have been torn.

The functional method of treatment is used, but the prognosis is not good and many patients complain of persistent pain radiating from the site of the fracture.

"BUTTERFLY" FRACTURE

This very rare injury is caused by hyperextension. A lateral x-ray shows that the front half of a vertebral body has been split into two triangular fragments which are hinged apart. The fracture is stable and is treated by active exercises, but the patient is warned not to hyperextend the spine.

FRACTURED TRANSVERSE PROCESS

This common fracture is caused by a flexion-rotation force. The muscles (psoas, quadratus lumborum and erector spinae) avulse one or more transverse processes.

The back is painful and tender and attempted movement produces spasm. An antero-posterior x-ray shows the fractures but not the extent of the injury, which is essentially to muscles.

The fracture is, of course, stable and should be treated by activity to prevent adhesions. If the injury is extensive the patient should remain in bed for 3–4 days. As soon as possible he is encouraged to get up and to practise vigorous exercises. The objects of treatment are to regain a full range of movement and to prevent adhesions.

FRACTURED LAMINA

Isolated fracture of a lamina, without dislocation, is rare, and is caused by a flexion-rotation injury. When it occurs above the fourth lumbar vertebra the fracture is said to be stable. No displacement occurs, and the injury may be treated in plaster or by the functional method.

At the fourth or fifth lumbar vertebra the fracture may be unstable; forward displacement of the vertebral column above the injury can occur, causing a traumatic spondylolisthesis. It is often difficult to decide whether the injury is a recent fracture or merely a sprain of the fibrous tissue with pre-existing spondylolisthesis. A true

days or weeks the flaccid paralysis becomes spastic, with increased tone, increased tendon reflexes and clonus; flexor spasms and contractures may develop but sensation never returns. The presence of anal and penile reflexes in the absence of sensation is diagnostic of cord transection.

ROOT TRANSECTION — Motor paralysis, sensory loss and visceral paralysis occur in the distribution of the damaged roots. Root transection, however, differs from cord transection in two ways: (*a*) regeneration is theoretically possible; and (*b*) residual motor paralysis remains permanently flaccid.

ANATOMICAL LEVELS

CERVICAL SPINE — With cervical spine injuries, the segmental level of cord transection nearly corresponds to the level of bony damage. Not more than one or two additional roots are likely to be transected. High cervical cord transection is fatal because all the respiratory muscles are paralysed. At the level of the fifth cervical vertebra cord transection isolates the lower cervical cord (with paralysis of the upper limbs), the thoracic cord (with paralysis of the trunk) and the lumbar and sacral cord (with paralysis of the lower limbs and viscera). With injury below the fifth cervical vertebra, the upper limbs are partially spared and characteristic deformities result.

BETWEEN FIRST AND TENTH THORACIC VERTEBRAE — The first lumbar cord segment in the adult is at the level of the tenth thoracic vertebra. Consequently, cord transection at that level spares the thoracic cord but isolates the entire lumbar and sacral cord, with paralysis of the lower limbs and viscera. The lower thoracic roots may also be transected but are of relatively little importance.

BELOW FIRST LUMBAR VERTEBRA — The cord ends at the lower border of the first lumbar vertebra. Fractures occurring below that level can produce only root lesions (of the cauda equina). The lumbar roots, however, stream downwards before emerging at their appropriate intervertebral levels; consequently, all the lumbar and the sacral roots are liable to damage.

BETWEEN TENTH THORACIC AND FIRST LUMBAR VERTEBRAE — A cord lesion may occur at any level in the lumbosacral cord. A fracture-dislocation of the twelfth thoracic on the first lumbar vertebra isolates the sacral cord; although the lumbar cord is spared, the lumbar roots may be transected.

The sacral cord innervates (*a*) sensation in the "saddle" area, a strip down the back of the thigh and leg, and the outer two-thirds of the sole; (*b*) motor power to the muscles controlling the ankle and foot; (*c*) the anal and penile reflexes, plantar responses and ankle jerks; and (*d*) control of micturition

The lumbar roots innervate (*a*) sensation to the entire lower limb other than that portion supplied by the sacral segment; (*b*) motor power to the muscles controlling the hip and knee; and (*c*) the cremasteric reflexes and knee jerks.

It is essential when the bony injury is at the thoracolumbar junction to distinguish between *cord transection with root escape* and *cord transection with root transection.* It will be seen that a patient with root escape is much better off than one with cord and root transection.

HOLD — A plaster jacket is applied and extends from the manubrium sterni to the symphysis pubis. It must be retained for at least 3 months and often for 6 months. Even then the natural process of repair by fusion between the damaged vertebrae is usually incomplete and a backbrace needs to be worn for a further 6 months.

EXERCISE — The patient stays in bed for 3-6 weeks. He then gets up and gradually increases muscle exercises within the plaster.

OPERATIVE TREATMENT

Although the closed method is safe, treatment is prolonged, and persistent pain and disability are very common. In many orthopaedic centres it has therefore been replaced by operative treatment.

REDUCE — The fracture is exposed, the ruptured supraspinous ligament acting as a valuable guide to the level of injury. Reduction is carried out under direct vision. Facetectomy may be necessary to allow reduction.

HOLD — Two vertebrae above and two below the level of the dislocation should be fixed together. One method is to raw the laminae and processes of the vertebrae, apply chip grafts and then to hold the spine in plaster.

An alternative method is to apply strong metal plates on each side of the spinous processes and bolt them together. For the next 4 weeks the patient is nursed in a posterior plaster shell. A plaster jacket is then applied in which the patient may get up. It is worn for a further 2 months and then replaced by a brace which is discarded 6 months after the injury.

EXERCISE — As soon as the plaster jacket has been applied extension exercises are begun and, when the brace is discarded, the patient gradually resumes full activity.

FRACTURES WITH PARAPLEGIA

Much of the following description of traumatic paraplegia is based upon that of Holdsworth.

VARIETIES OF LESION

In traumatic paraplegia the displaced structures have damaged the cord, or nerve roots, or both; the damage may be temporary or permanent. Three varieties of lesion may occur.

CORD CONCUSSION — Motor paralysis (flaccid), sensory loss and visceral paralysis occur below the level of the cord lesion. The disturbance is one of function without a demonstrable anatomical lesion Recovery begins within 8 hours and eventually becomes complete.

CORD TRANSECTION — *Motor paralysis, sensory loss and visceral paralysis occur below* the level of the cord lesion; as with cord concussion the motor paralysis is at first flaccid. This temporary condition is known as cord shock. The injury is anatomical and irreparable.

After a time, however, the cord below the level of transection recovers from the shock and acts as an independent structure; that is, it manifests reflex activity. In a few hours the anal and penile reflexes return, and the plantar responses become extensor. In a few

Promote periodicity — To promote periodicity, the patient closes the clip on the rubber tube and opens it at intervals, when he attempts to pass urine with the help of manual compression over the bladder, straining, or tickling his thigh. At the weekly catheter changes the catheter is left out for a few hours to assess returning function. When the cord lesion is incomplete, *periodic function can usually be established in 6–8 weeks;* with a complete lesion, the process takes 2–3 months. During and after training it is important to assess at intervals the quantity of residual urine; if it is too high, punch resection of the bladder neck may be needed. If training fails, the patient is condemned to wearing a urinal or using a penile clamp.

The bowel is more easily trained, with the help of enemas, aperients and abdominal straining.

MUSCLES AND JOINTS — The paralysed muscles, if not treated, may develop severe flexion contractures. These are usually preventable by moving the joints passively through their *full range twice daily.* Later, splints become necessary.

With lesions below the cervical cord, the patient should be up within 3 months; standing and walking are valuable in preventing contractures. Calipers are usually necessary to keep the knees straight and the feet plantigrade. The calipers are removed at intervals during the day while the patient lies prone, and while he is having physiotherapy. The upper limbs must be trained until they develop sufficient power to enable the patient to use crutches and a wheelchair.

If flexion contractures have been allowed to develop, tenotomies may be necessary. Painful flexor spasms are rare unless skin or bladder infection occurs. They can sometimes be relieved by tenotomies, neurectomies, rhizotomies or the intrathecal injection of alcohol.

MORALE — The morale of a paraplegic patient is liable to reach a low ebb, and the restoration of his self-respect and self-confidence is an important part of treatment. Constant enthusiasm and encouragement by doctors, physiotherapists and nurses is essential. Their scrupulous attention to his *comfort and toilet are of primary importance;* the unpleasant smells associated with skin or urinary infection must be avoided. The earlier the patient gets up the better, and he must be trained for a new job as quickly as possible.

TREATMENT OF THE BONES

CERVICAL SPINE — In the presence of paraplegia, fractures and dislocations of the cervical spine should be reduced, and held reduced by means of skull traction. Subsequently, the neck may be immobilized in plaster but internal fixation with bone grafts or wires is more reliable (*see* pages 310–311).

THORACOLUMBAR SPINE

Closed treatment — Closed treatment is feasible but difficult for, if plaster is used, sores inevitably develop in anaesthetic skin. Guttmann has shown that it is possible to treat the patient on a flat bed with a thick Sorbo mattress and flanked by supporting Sorbo pillows; he can be gently turned for nursing purposes, but constant and unremitting care is required.

Operative treatment — Operative treatment with internal fixation makes nursing much

SIGNS

The signs of the fracture itself are those of an unstable fracture without paraplegia (*see* page 315). Clinical examination of the back is however unnecessary, for neurological disturbance denotes an unstable fracture. The nature and level of the bone lesion are demonstrated by x-ray.

NEUROLOGICAL — The neurological signs are important and nearly always permit accurate diagnosis (and prognosis).

(*a*) The level of the neurological lesion is deduced from x-ray.

(*b*) The cord is only concussed if some sensation and power are present below the affected level (for recovery has almost always begun by the time the patient reaches hospital).

(*c*) The cord is transected if sensation is absent but penile and anal reflexes are present.

(*d*) Root transection is indicated by the absence of sensation and power in segments higher than the cord lesion; and root escape by the presence of some sensation or power.

MANAGEMENT OF TRAUMATIC PARAPLEGIA

The outlook for a paraplegic patient used to be appalling; with modern methods of treatment his life can be made tolerable. Management in the first 24 hours is all-important for his future.

The patient must be transported with great care to avoid further damage. If possible, he should be taken direct to a special paraplegia centre.

The early treatment of skin and bladder takes priority; the care of the bowels is the next consideration and then comes the treatment of muscles and joints; the bony injury is dominated by the cord injury and will be considered last.

SKIN — Within a few hours anaesthetic skin may develop enormous pressure sores; this must be prevented by meticulous nursing. Creases in the sheets and crumbs in the bed are not permitted. Every 2 hours the patient is gently rolled onto his side and his back is carefully washed (without rubbing), dried and powdered. After a few weeks the skin becomes a little more tolerant and the patient can turn himself. If sores have been allowed to develop they may never heal without excision and skin grafting.

BLADDER AND BOWEL — For the first 24 hours the bladder distends only slowly, but, if the distension is allowed to progress, overflow incontinence occurs and infection is probable. *The treatment described below is a summary of that advocated by Hardy.* The essentials are to prevent distension, to prevent shrinkage, to avoid infection and to promote periodicity.

Prevent distension — An indwelling urethral catheter is used (self-retaining Foley type, 16 or 18 French gauge). Urine drains through a rubber connexion into the collecting jar. The catheter is changed at weekly intervals; a strict aseptic ritual is essential whenever the catheter is handled. If infection has not been prevented, antibiotics, especially sulphonamides, are useful

Avoid infection — Twice daily the bladder is washed out with Suby's solution M, and thoroughly evacuated by syringe suction When bladder tone begins to return a closed system of irrigation is used, with the jar raised and lowered alternately to fill and empty the bladder.

COMPRESSION — An antero-posterior crushing force fractures both pubic rami on both sides, and the central segment may be pushed backwards, endangering the urethra.

HINGE — The force is applied to one blade of the ilium and "opens" the pelvis; for example, when a patient is partially run over. One half of the pelvis is intact; the other half is damaged both in front (the pubis is fractured or the symphysis forced open) and at the back (the ilium is fractured or the sacroiliac joint forced open).

VERTICAL FORCE — The patient falls from a height onto one leg. The pubis and ilium on the same side are both fractured; the portion of pelvis lateral to the fractures is pushed upwards.

SYMPTOMS

Pain is considerable and is worse on coughing or moving. The patient is aware of severe pelvic damage; he cannot stand and may be unable to pass urine.

GENERAL SIGNS

Shock may be severe. Haemorrhage into the pelvis is often considerable. Urogenital damage may be indicated by the presence of blood at the external meatus.

LOCAL SIGNS

LOOK — There may be a graze or bruising and swelling.

FEEL — Although tenderness is often too great or too diffuse to be of diagnostic value, marked suprapubic tenderness suggests urogenital damage (mainly in compression fractures). A gap at the symphysis is occasionally felt (in hinge fractures) and one leg may be partly anaesthetic because of sciatic-nerve damage (in vertical force fractures).

MOVE — Movements should not be attempted.

X-RAY — The films show the type of fracture.

Compression — Both pubic rami are fractured on both sides.

Hinge — There is a gap at the symphysis, and sacroiliac subluxation, or fractures near these two sites.

Vertical force — The pubis and the ilium on the same side are fractured; there is upward shift lateral to the fractures.

EMERGENCY TREATMENT

The treatment of shock has been described on page 261.

UROGENITAL DAMAGE — Damage to the urogenital tract is unlikely except with compression fractures, and the diagnosis is usually obvious because there is severe pain and profound shock, and blood appears at the meatus. If these are present, diagnostic instrumentation is unnecessary and harmful. The patient should be resuscitated, and detailed examination postponed until he has been anaesthetized in preparation for operation.

Even when these signs are lacking, it is still necessary to exclude urogenital tract damage in all pelvic ring disruptions. A soft rubber catheter is passed. If clear urine emerges, and a measured volume of introduced fluid can be withdrawn, the tract is undamaged.

simpler; moreover, fixation "splints" the damaged nerve roots and may facilitate their regeneration. Four vertebrae are exposed, two above and two below the level of injury, and strong plates on either side of the spinous processes are bolted firmly together.

FRACTURES OF THE PELVIS

Fractures of the pelvis fall into four groups.

ISOLATED PELVIC RING FRACTURES — The ring is broken in only one place, displacement is slight and complications are rare.
PELVIC RING DISRUPTIONS — The ring is broken in two places, displacement may be severe and complications are common.
AVULSION FRACTURES — These are relatively unimportant traction injuries.
SACROCOCCYGEAL INJURIES

ISOLATED PELVIC RING FRACTURES

MECHANISM

A direct blow on the side or front of the pelvis may fracture the ilium, the acetabulum, or the pubic rami on one side. The pelvic ring is broken in only one place, displacement is slight and intrapelvic structures are not damaged.

SIGNS

LOOK — Bruising may be evident.
FEEL — There is tenderness at the site of impact, and springing the pelvis may be painful.
MOVE — Usually the patient can lift his leg and as a rule he can stand on it (unless a fractured acetabulum is associated with central dislocation of the hip).
X-RAY — The films may show one of three injuries: (*a*) fractured wing of the ilium, often with displacement; (*b*) fractured acetabular floor, possibly in association with a central dislocation of the hip, or (*c*) fracture of the front of the pelvis on one side only; either or both rami of the pubis may be fractured.

It is important to be sure that the sacroiliac joints are both undamaged, for if a fracture in front is combined with sacroiliac subluxation, pelvic ring disruption has occurred.

TREATMENT

Isolated fractures of the ilium and pubis need not be reduced or held. The patient stays in bed until he is comfortable, and is then taught to stand and walk. With an isolated fracture, there are no complications.

Fractures of the acetabulum associated with central dislocation of the hip are considered on page 332.

PELVIC RING DISRUPTIONS

MECHANISM

The ring is broken in two places; displacement may be considerable. Perkins has pointed out that there are three distinct varieties of fracture, each caused by a different force.

MOVE — Resisted action of the affected muscle is painful.
X-RAY — Avulsion may be seen at one of three sites: (*a*) anterior superior iliac spine (sartorius avulsion); (*b*) anterior inferior iliac spine (rectus avulsion, which must be distinguished from an os acetabuli); or (*c*) ischial tuberosity (hamstrings avulsion).

TREATMENT

Reduction is unnecessary. The patient is rested for a few days with the injured muscle in a relaxed position for comfort. Then normal activities are resumed. Ultimately function becomes normal.

INJURIES TO SACRUM AND COCCYX

MECHANISM

A blow from behind, or a fall onto the "tail" may fracture the sacrum or coccyx, or sprain the joint between them.

SIGNS

LOOK — A bruise is occasionally seen.
FEEL — Tenderness is elicited when the sacrum or coccyx is palpated from behind or per rectum. Sensation may be lost over the distribution of sacral nerves.
MOVE — Movement is unaffected.
X-RAY — The films may show (*a*) a transverse fracture of the sacrum, in rare cases with the lower fragment pushed forwards; (*b*) a fractured coccyx, sometimes with the lower fragment angulated forwards; or (*c*) a normal appearance if the injury was a sprain of the sacro-coccygeal joint.

TREATMENT

REDUCE — If the fracture is displaced, reduction is worth attempting. The lower fragment may be pushed backwards per rectum.
HOLD — The reduction is stable, which is fortunate.
EXERCISE — The patient is allowed to resume normal activity, but is advised to use a rubber ring or Sorbo cushion when sitting.

COMPLICATIONS

Persistent pain, especially on sitting, is common after coccygeal injuries. If the pain is not relieved by the use of a Sorbo cushion or by the injection of local anaesthetic into the tender area, excision of the coccyx may be considered.

Suggestions for further reading

Birkett, A. N. (1950) "Injuries and Derangements of the Spinal Column." In *Modern Trends in Orthopaedics*. 1st Series. Ed. by Sir H. Platt. [illegible]
[illegible] *J. Bone* [illegible]
[illegible] *Soc. Med*, 40, 19. [illegible]

Intrapelvic rupture of the urethra — This, the commonest variety of urogenital damage, is treated as follows: the bladder is opened and a suprapubic sound is used to guide a urethral sound up into the bladder. By "railroading", a self-retaining catheter is introduced. The bladder is sutured and the cave of Retzius drained.

Bladder rupture — Rupture of the bladder may be intraperitoneal or extraperitoneal. In either case the tear is sutured and the bladder and cave of Retzius are drained.

TREATMENT OF THE FRACTURE

COMPRESSION TYPE — Reduction is neither possible nor necessary; consequently splintage is not required. The patient lies free in bed for 3 weeks, and gradually increasing active movements of the hip and spine are encouraged. After 3 weeks he gets up; he is allowed to take weight thus early because the line of weight transmission does not pass through the fracture area.

HINGE TYPE — Under anaesthesia the patient is rolled onto the unaffected side of the pelvis The surgeon leans on the upper half of the pelvis and by this means "closes" the pelvis. The manœuvre is simple and effective.

Reduction is stable, and a firm binder or lumbosacral corset is sufficient protection. For the first 3 weeks the patient remains in bed, but is encouraged to move the limbs He is then allowed up, using crutches at first, and within 6 weeks should have regained full activity. The corset is discarded after 3 months.

VERTICAL FORCE TYPE — Under anaesthesia, the leg on that side of the pelvis which has shifted upwards is forcibly pulled down. Skeletal traction is applied and the patient remains on traction for 12 weeks, when the fracture will have united but not consolidated. Traction is then removed, and the patient allowed up with crutches. He must not take weight for 3 months from the injury.

COMPLICATIONS

The complications common to all types of ring disruptions are shock, intrapelvic haemorrhage and paralytic ileus

The complications specific to each type of fracture are urogenital damage in compression fractures, especially in run-over accidents, persistent sacroiliac pain after hinge fractures (arthrodesis of the sacroiliac joint may prove necessary), and sciatic nerve injury in vertical force fractures (usually the nerve recovers, but occasionally exploration later proves necessary).

AVULSION FRACTURES

MECHANISM

Violent muscle action in an athletic adolescent may avulse a traction epiphysis (apophysis). The muscles concerned are the sartorius, rectus femoris and the hamstrings.

SIGNS

LOOK — The appearance is normal

FEEL — The site of avulsion is tender.

CHAPTER 24

FRACTURES AND DISLOCATIONS IN THE LOWER LIMB

NECK OF FEMUR

CERVICAL FRACTURES (*see also* page 329)

MECHANISM

THE injury occurs mainly among elderly women. The patient may fall, but often merely catches her foot while walking; the foot is then twisted outwards and the rotation force breaks the neck of the femur.

The neck of the femur may be weak as the result of senile osteoporosis or because it is the site of a secondary deposit.

SIGNS

LOOK — The leg is slightly short and lies externally rotated.

FEEL — The great trochanter is too high and too far posterior.

MOVE — The patient cannot lift her leg.

X-RAY — The fracture may be situated high in the neck (subcapital) or lower (trans-cervical). The obliquity of the fracture line is difficult to determine because of displacement; it is relatively vertical and the more vertical it is, the less favourable the prognosis. The shaft is displaced upwards and rotated outwards.

TREATMENT

Operative methods with internal fixation are almost invariably used because neither traction nor plaster holds the fragments sufficiently immobile and because, in the aged, it is important to get the patient up and about as soon as possible. It may be expedient to postpone operation for a few days; skin traction is applied and the patient is taught breathing exercises. The delay is not essential but may allow the patient's general condition to improve; moreover the traction may facilitate the subsequent manipulative reduction.

REDUCE — The patient is placed on an orthopaedic table in a position which permits the taking of antero-posterior and lateral x-ray films.

The fractured thigh is pulled upwards with the hip and knee flexed, and the limb is then internally rotated, extended and abducted. With the leg in this position, the foot is tied to a footpiece. Metal skin clips are applied as markers and antero-posterior and lateral films are taken to confirm reduction. Unless the fracture is correctly reduced it must not be nailed, and the attempted reduction must be repeated.

Guttmann, L. (1954). "Initial treatment of Traumatic Paraplegia." *Proc. R. Soc. Med.*, 47, 1103.

Hardy, A. G. (1954). "Early Treatment of the Bladder in Traumatic Paraplegia." *J. Bone Jt Surg.*, 36B, 368.

Holdsworth, F. W. and Hardy, A. G. (1953). "Early Treatment of Paraplegia from Fractures of the Thoraco-lumbar Spine." *J. Bone Jt Surg.*, 35B, 540.

— (1956). "Traumatic Paraplegia." In *Modern Trends in Orthopaedics*. 2nd Series. Ed. by Sir H. Platt. London; Butterworth.

Kaplan, C. J. (1953). "Cervical Hyperextension Injuries with Paraplegia." *J. Bone Jt Surg.*, 35B, 97.

... of the Dorso-lumbar Spine." *J. Bone Jt*

... ssification of Fractures of the Pelvis." *Proc.*

Sometimes the nail is extruded after apparent union of the fracture; a line of separation then develops between living and dead bone, with subsequent refracture.

The avascular head cannot withstand weight; even when the nail remains in it until the fracture has consolidated, the head will crush and osteoarthritis will result.

Early diagnosis — An experimental method which may permit early diagnosis of avascularity is as follows: 1 hour before the nailing operation, radioactive phosphorus (^{32}P) is injected intravenously. At operation, a specially designed Geiger counter is inserted through a narrow hole drilled up the neck into the head. If the head is avascular it will not have taken up the normal amount of ^{32}P and the counter reading will be much lower than that in the neck.

DELAYED UNION — This is especially liable to occur if the blood supply to the femoral head is inadequate.

If the head shows increased density on x-ray and the nail is still in position, weight bearing should be avoided until revascularization has occurred. This may, however, prove impracticable in the elderly.

If the pin is extruded it should be hammered back and held in position with a plate screwed to the upper femoral shaft. If possible, weight bearing should be avoided for many months.

When the radioactive method described above becomes sufficiently established to enable diagnosis of avascular necrosis to be made at the primary operation, the ideal treatment may well prove to be immediate osteotomy or replacement of the femoral head by a metal prosthesis.

NON-UNION — Non-union is liable to occur if the fracture line is unduly vertical, the operation is unskilfully performed (inaccurate reduction or bad nailing), or if the blood supply to the femoral head is diminished.

Conservative treatment — If the main symptoms are shortening and a limp, a raised heel, physiotherapy and a stout stick or elbow crutch are often sufficient.

Operative treatment — Operation is necessary if the above symptoms are accompanied by considerable pain, which is often the case. The choice of operation usually depends upon the cause of non-union.

(a) If the fracture line is unduly vertical an osteotomy is useful. The femur is divided obliquely from below the great trochanter to just above the lesser trochanter. The upper shaft is pushed medially and the lower shaft held abducted in plaster; when the osteotomy has joined, the plaster is removed and, as the leg adducts, the fracture line becomes more horizontal, so that impaction and union are likely to occur. To minimize stiffening of the knee, the osteotomy may be held by a metal plate and plaster dispensed with

(*b*) If the reduction or the nailing were faulty, but the head is not avascular, it is reasonable to remove the nail, reduce the fracture, insert a fresh nail correctly and to place a fibular graft across the fracture.

(*c*) If the head is avascular, the choice lies between an abduction osteotomy as above and excision of the dead head. Excision may be followed by traction for 6 weeks and a caliper for 6 months (Girdlestone's technique), or the excised head may be replaced by a metal prosthesis.

HOLD — (1) A longitudinal incision is made distal to the great trochanter and is deepened to expose the lateral aspect of the upper femur.

(2) A guide wire of known length is inserted through the lateral cortex, along the neck into the femoral head. Antero-posterior and lateral films are taken to show if the guide wire is in the desired position. If not, further guide wires are introduced until one is satisfactory. Ideally the guide wire should lie in the lower half of the neck (so that the nail will have a firm hold in the calcar femorale) and should enter the head just posterior to its centre.

(3) A cannulated trifin nail is selected. It should be of such a length that its lateral end will abut against the outer femoral cortex when the inner end is just short of the articular cartilage of the head. This length is determined by measuring the length of guide wire protruding from the femur and by inspecting the x-ray films.

(4) The nail is threaded over the guide wire and a cannulated punch is used to hammer it in. Care must be taken that the guide wire is not driven in. When the nail has been hammered home the guide wire is removed

When the check x-rays show the position of the nail to be satisfactory the wound is sutured and the patient returned to bed.

EXERCISE — From the first day the patient should sit up in bed or in a chair. She is taught breathing exercises and to move the hip and knee gently.

After 4 weeks she is taught to use crutches, but must avoid taking weight through the injured leg (this may be a counsel of perfection in the decrepit).

After 8 weeks some weight bearing is permitted but most of the body weight is still taken through crutches.

After 12 weeks the crutches are replaced by two sticks, which are discarded when possible.

X-ray films are taken before each advance is permitted. The patient is x-rayed every 3 months for 1 year and every 6 months for 3 years.

COMPLICATIONS

General complications such as follow any injury or operation in the elderly are liable to occur, especially calf-vein thrombosis, pulmonary embolism, pneumonia and bed sores. Local complications are as follows.

AVASCULAR NECROSIS — This is an important and common complication The femoral head is supplied by foveolar, nutrient and retinacular arteries. The blood flow through them may be interrupted by the fracture or its treatment.

The increased density on x-ray which is characteristic of avascular necrosis may not become apparent for many weeks, months or even years; probably because, so long as the nail holds the fracture, the patient can move the limb and consequently little surrounding bone atrophy occurs

Avascular necrosis may result in redisplacement of the fracture, in refracture after apparent union, or in osteoarthritis after consolidation.

The first indication of avascular necrosis is usually the nail extruding from the head or breaking out of it. The fracture then redisplaces and, if the condition is untreated, non-union occurs.

HOLD — Using methods similar to those used for a cervical fracture, a trifin nail is inserted into the femoral neck and head; a plate is attached to the nail and screwed to the upper femoral shaft.

EXERCISE — The patient is assisted to sit up and get up as soon as possible. If the fracture is of the stable variety (intact medial cortical buttress) weight bearing is permitted at once, otherwise crutches are used.

COMPLICATIONS

The general complications are the same as those following cervical fractures. There is only one local complication, namely secondary mal-union. When the fracture is of the unstable variety, weight bearing is liable to be followed by the development of coxa vara. The only treatment necessary is a raised shoe.

UNCOMMON FRACTURES OF THE FEMORAL NECK

IMPACTED FRACTURE

Sometimes a cervical fracture in an elderly person is impacted. The patient can lift the leg and walk. It may well be that many patients with impacted fractures are never sent to hospital. On x-ray, not only is the fracture seen to be impacted, but the fracture line is relatively horizontal.

These fractures nearly always unite satisfactorily without treatment. Walking probably augments the impaction. There is, however, a slight risk that, while the patient is lying in bed, the weight of the limb may impose an external rotation force and disimpact the fracture. For this reason some surgeons advocate nailing all fractures even if impacted. Probably the only treatment necessary is to provide the patient with a slipper to which an external rotation stop is attached. This is worn at night, and during the day the patient walks about normally.

FRACTURES IN THE YOUNG

The femoral neck breaks in young people only if subjected to considerable force. A child is treated by closed reduction and plaster, but in adults internal fixation is usually preferred. There is a relatively high incidence of avascular necrosis; the patient should not take weight through the leg for at least 6 months, and then only if the x-ray appearance of the femoral head is normal.

EPIPHYSEAL AVULSIONS

In adolescents, the lesser trochanter epiphysis may be avulsed by the pull of the psoas muscle. The injury nearly always occurs during hurdling. An even less common injury is avulsion of the greater trochanter by the abductor muscles. With either injury the patient needs rest in bed for only 2–3 days and may then get up with crutches. As soon as he can balance on the affected leg he may discard the crutches. He is unlikely to resume full athletic activities until the following season.

PATHOLOGICAL FRACTURES

It has already been mentioned that fractures in the elderly often occur through osteoporotic bone and occasionally through a secondary deposit. "Spontaneous" fracture of the femoral neck may occur after radiotherapy to the hip region.

Note — With a high subcapital fracture and a vertical fracture line the chances of union following nailing are slender. It is not unreasonable to excise the head and insert a metal prosthesis as the primary operation. This method is on trial; its results are inferior to those following successful nailing.

JOINT STIFFNESS — The hip joint may lose mobility because of osteoarthritis, which is especially liable to follow union in the presence of avascular necrosis of a segment of the head. If pain is sufficient to justify operation the possibilities are osteotomy, or replacement of the head by a metal prosthesis. Arthrodesis and cup arthroplasty are impracticable.

NERVE LESIONS — Nerve injury is almost unknown as a direct complication of the fracture, but it may follow bad treatment. If the fractured limb is allowed to lie in full external rotation, lateral popliteal palsy may develop; and if the patient is not taught to use crutches correctly, a radial palsy may occur.

TROCHANTERIC FRACTURES

MECHANISM

The patient stumbles or falls. The fracture may be due to an external rotation force applied to the foot, or may result from the fall. The fracture line is lateral to the insertion of the capsule of the joint, so that considerable displacement readily occurs.

SIGNS

The patient is almost invariably elderly and not uncommonly a hemiplegic.

LOOK — The leg lies fully externally rotated and is short.
FEEL — The great trochanter is unduly high and unduly posterior.
MOVE — The patient cannot lift the leg.
X-RAY — The fracture line runs obliquely across the bone in the region of the trochanters. The shaft is displaced upwards and rotated outwards. The cortical buttress on the medial side above the lesser trochanter should be inspected; if it is intact, the fracture will, after operation, be stable to weight bearing

CLOSED TREATMENT

REDUCE — Skin or skeletal traction readily reduces the fracture.
HOLD — Traction must be maintained for 3 months. The fracture will then have united, but not consolidated. The patient may get up, but must use crutches and avoid taking weight for a further 3 months until the fracture has consolidated.
EXERCISE — Breathing exercises are started at once and all joints are exercised regularly. Bed sores can be avoided by good nursing

OPERATIVE TREATMENT

Trochanteric fractures always unite however treated. The advantage of operative fixation is that an elderly patient is enabled to move freely and to get up with little delay.

REDUCE — With the anaesthetized patient on an orthopaedic table, the fracture is reduced by extending the leg, abducting it 40 degrees and rotating it until the patella faces the ceiling.

HOLD — Using methods similar to those used for a cervical fracture, a trifin nail is inserted into the femoral neck and head; a plate is attached to the nail and screwed to the upper femoral shaft.
EXERCISE — The patient is assisted to sit up and get up as soon as possible. If the fracture is of the stable variety (intact medial cortical buttress) weight bearing is permitted at once, otherwise crutches are used.

COMPLICATIONS

The general complications are the same as those following cervical fractures. There is only one local complication, namely secondary mal-union. When the fracture is of the unstable variety, weight bearing is liable to be followed by the development of coxa vara. The only treatment necessary is a raised shoe.

UNCOMMON FRACTURES OF THE FEMORAL NECK

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COMPLICATIONS

ASSOCIATED FRACTURE

Fractured acetabulum — A triangular fragment of the acetabulum may have been sheared off during dislocation; it usually falls into place when the hip is reduced and the only special precaution then necessary is to defer weight bearing for 12 weeks. If the fragment remains displaced, it should be reduced at open operation and fixed in position with a screw, otherwise the hip may dislocate again.

Fractured femoral head — The dislocation may have sheared off a segment of the femoral head. As a rule reduction of the dislocation automatically reduces the fracture, but weight bearing must be deferred for at least 12 weeks. If the head fragment has not been correctly reduced its excision provides the only hope of regaining reasonable movement at the hip.

JOINT STIFFNESS

Avascular necrosis — The blood supply of the femoral head is seriously reduced in at least 20 per cent of traumatic hip dislocations; if reduction is delayed by more than a few hours, the figure rises to 50 per cent. Avascular necrosis shows on x-ray as an increase in the density of the femoral head; but this change is not seen for at least 6 weeks, and sometimes very much longer.

If weight is taken through an avascular head, it crushes and degenerative arthritis is inevitable. If avascular necrosis is diagnosed before the head has begun to crush, and the patient is relatively young, it is conceivable that the avoidance of weight bearing for a period of up to 2 years might allow the head to revascularize. In most cases, however, the avascular necrosis quickly leads to degenerative arthritis; the head is then best excised and replaced by a metal prosthesis.

Myositis ossificans — It is essential after any injury to prohibit passive movements. Even if they are not the sole cause of myositis ossificans they certainly increase its severity. At the first suggestion of calcification around the hip, the joint should be rested in a hip spica. The final range will inevitably be restricted.

Unreduced dislocation — If a dislocation has remained untreated for more than a few weeks its reduction is very difficult, whether by manipulation or operation. Even if reduction can be achieved, avascular necrosis is almost inevitable. Probably the choice of treatment lies between replacement of the head by a metal prosthesis and subtrochanteric osteotomy.

NERVE LESIONS — The sciatic nerve is sometimes damaged but usually recovers. Following reduction of a dislocated hip, if a sciatic nerve lesion and an unreduced acetabular fracture are diagnosed, the nerve should be explored and the fragment correctly replaced.

ANTERIOR DISLOCATION

MECHANISM

Nowadays the commonest cause of anterior hip dislocation (which is less common than posterior dislocation) is a weight falling onto the back of a miner or building labourer who is working with his legs wide apart, knees straight and back bent forwards. One or both hips may be dislocated.

In adolescents the upper femoral epiphysis may slip (*see* page 200), a condition comparable to a fractured neck of femur.

In children, the neck of the femur may fracture through a solitary cyst.

DISLOCATION OF THE HIP

POSTERIOR DISLOCATION

MECHANISM

The hip may be dislocated posteriorly when the bent leg is violently thrust backwards, as when a car hits a tree and the passenger's knee is struck by the dashboard. The impact is liable to fracture the acetabular roof, which displaces with the femoral head; only when the hip is adducted at the moment of impact is dislocation likely to occur without fracture.

With the enormous increase in road accidents, posterior hip dislocation is no longer a rare injury.

SIGNS

LOOK — The leg is short and lies adducted, internally rotated and slightly flexed.

FEEL — The femoral head cannot be felt in its socket, but may be palpable on the dorsum ilii

MOVE — No movement is possible.

X-RAY — In the antero-posterior film the femoral head is seen out of its socket and above the acetabulum. A segment of acetabular roof may have been broken off and displaced upwards A lateral film is not essential because, if the head has shifted upwards, the dislocation is always posterior.

TREATMENT

REDUCE — Deep anaesthesia is essential, preferably with a relaxant. Reduction is more easily effected with the patient lying on a mattress on the floor. An assistant steadies the pelvis, the surgeon flexes the patient's hip and knee to 90 degrees and pulls the thigh vertically upwards. Usually this manœuvre effects reduction, but sometimes it is necessary also to abduct the flexed hip X-ray examination is essential to confirm reduction and to exclude a fracture

HOLD — Reduction is stable, but the hip has been severely injured and needs to be rested. The simplest treatment is to apply skeletal traction behind the tibial tubercle and maintain it for 6 weeks. Alternatively, a plaster spica may be applied with the hip in neutral position

EXERCISE — If the patient is being treated on traction active exercises are permitted, but passive movements are prohibited for fear of myositis ossificans. Plaster immobilization has the advantage that it prevents passive movements

At the end of 6 weeks, plaster or traction is removed and the hip x-rayed In the absence of an associated fracture, myositis ossificans or avascular necrosis, weight bearing is permitted.

If reduction has been delayed by more than a few hours, it is wise to postpone weight bearing for at least 12 weeks and then to permit it only if the density of the head is normal.

SUBTROCHANTERIC FRACTURES

MECHANISM

This injury is not uncommon in the elderly following a fall. Sometimes the fracture is pathological, through an area of Paget's disease. The head and neck of the femur are abducted by the gluteal muscles, and flexed by the psoas muscle.

SIGNS

LOOK — The leg lies externally rotated and is short.
FEEL — Palpation is of little value.
MOVE — The patient cannot lift the leg.
X-RAY — The fracture is slightly below both trochanters. It may be transverse or oblique. The shaft of the femur is shifted medially, may be displaced upwards, and often lies behind the upper fragment.

TREATMENT

REDUCE — The fracture is reduced by strong traction and abduction.

HOLD — Reduction can be maintained only if the flexed abducted position is held. This may be achieved in one of three ways:
Plaster — If reduction appears stable, a plaster spica may be applied, holding the hip widely abducted and flexed. An x-ray film must then be taken to ensure that the fragments are in position. The spica is retained for 3 months.
Continuous traction — If the fracture does not appear stable, reduction can be maintained by continuous strong traction (skin or skeletal). The leg may be cradled on pillows, or on a Thomas splint suspended from a Balkan beam, or the patient may be treated on an abduction frame. Traction is maintained for 3 months.
Internal fixation — In the middle aged or elderly, internal fixation is advisable. A high subtrochanteric fracture is held by means of a trifin nail inserted up the neck of the femur and attached to a strong plate screwed to the femoral shaft well below the fracture line. Lower fractures are best held by means of an intramedullary nail; with internal fixation, no other splintage is necessary.

EXERCISE — If plaster has been used it is removed after 3 months; movements are regained by active exercises. Weight bearing is avoided for a further 3 months until consolidation has occurred.

During treatment by traction, the muscles are repeatedly exercised; movement is regained when traction is discontinued. Weight bearing must be avoided for 6 months from the date of injury.

If internal fixation has been used, the patient practises active movements immediately. He is allowed up using crutches and within 6 weeks may begin partial weight bearing. Full weight bearing is permitted at 3 months.

FEMORAL SHAFT FRACTURES

MECHANISM

A spiral fracture is usually caused by a fall in which the foot is anchored while a twisting force is transmitted to the femur. An angulation force or a direct injury

SIGNS

LOOK — The leg lies externally rotated, abducted and slightly flexed. It is not short, because the attachment of the rectus femoris muscle prevents the head from displacing upwards.

FEEL — The head feels too prominent.

MOVE — Movements are impossible.

X-RAY — The head is seen to be dislocated and lies below the level of the acetabulum.

TREATMENT

The manœuvres employed are almost identical with those used to reduce a posterior dislocation, except that while the flexed thigh is being pulled upwards, it should be adducted. The subsequent treatment is similar to that employed for posterior dislocation.

COMPLICATIONS

Avascular necrosis is the only complication.

CENTRAL DISLOCATION

MECHANISM

The patient falls directly onto the great trochanter and the force fractures the acetabular floor and thrusts the femoral head into the pelvis. Typically, the injury occurs when a man alighting from a train in the dark unexpectedly finds no platform.

SIGNS

LOOK — The trochanteric region is grazed or bruised, but the leg lies in normal position.

FEEL — The trochanter and hip region are tender.

MOVE — Little movement is possible.

X-RAY — The femoral head is displaced medially, and the acetabular floor fractured.

TREATMENT

REDUCE — The surgeon pulls strongly on the thigh and then tries to lever the head outwards by adducting the thigh, using his fist in the groin as a fulcrum. In the middle aged or elderly patient it is wise to be content with even imperfect reduction. In a young patient, if closed reduction fails and the acetabular fragment is not comminuted, the displacement may be reduced at open operation and the fragment fixed with a screw.

HOLD — Skeletal traction behind the tibial tubercle is applied and a 15-pound pull maintained for 6 weeks.

EXERCISE — Gentle active use is encouraged from the start. When traction is removed the patient is allowed up with crutches, and full movements are encouraged. Weight bearing is permitted after 12 weeks. Even when reduction has been imperfect, the final functional result is much better than the x-ray appearance would suggest.

advanced the patient may be allowed up wearing a weight-relieving caliper without a knee hinge. A caliper does not effectively control fractures above the mid-shaft; for these it is safer to maintain fixed traction until consolidation is complete. Splintage must not be discarded until consolidation is clinically and radiologically complete.

EXERCISE — The patient is taught to lift himself by a "monkey pole" and to exercise all joints not immobilized.

He is also taught quadriceps muscle exercises. These must be practised assiduously and repeatedly and are of the utmost importance if knee stiffness, the great bugbear of femoral shaft fractures, is to be avoided.

Once the patient is up, the caliper is taken off at intervals during the day for knee-bending exercises without taking weight. When consolidation is complete and the splint has finally been discarded, these exercises are intensified, but it will be many months before full knee movement returns.

TREATMENT BY BALANCED TRACTION ON A THOMAS SPLINT

As with fixed traction, a Thomas splint with slings and pads is used; to provide counter-traction the splint is tied to the raised foot of the bed or to an overhead beam. The traction, however, is skeletal, through a Steinmann or Denham pin behind the tibial tubercle. Weights (20 pounds for an adult) are attached but are not fixed to the cross-piece of the splint; they hang over pulleys at the foot of the bed. The position of the limb is carefully watched and x-ray films taken as necessary. From time to time the pads, slings, or pulleys need adjustment. With transverse fractures it is especially important to avoid overpulling, which inevitably delays union.

As soon as the patient can lift the straight leg from the splint, knee-flexion exercises are begun, for alignment is maintained by the weights. Once union is well advanced a caliper is fitted. Knee flexion returns more readily than with the fixed traction method.

TREATMENT BY BALANCED TRACTION WITHOUT SPLINT

It is not generally appreciated that the Thomas splint does not really "immobilize" the fracture. Essentially it is a device for the attachment of slings and strings.

The simplest method of holding reduction is by traction without a splint. Skeletal traction is used for adults and skin traction for children. Weights are attached and hung over pulleys at the foot of the bed, which is raised. The leg is merely cradled on pillows, which also serve to prevent backward sag. Quadriceps muscle exercises are started at once and, as soon as the patient can lift his leg, knee-bending exercises are begun.

This method is certainly adequate for a child, and for a spiral fracture in an adult. Perkins has shown convincingly that it is both comfortable and effective even with a transverse fracture in an adult, provided that the muscles are repeatedly exercised, for the muscles splint the fracture. It is, however, a method which requires constant supervision, and is not to be used by the inexperienced. As with other methods, a caliper may be fitted once union is well advanced.

In children, as soon as the fracture has united, a plaster spica including the hip,

may cause a transverse fracture, which is particularly common in motorcycle accidents. A transverse fracture occurring after middle life should be viewed with suspicion; it may be pathological.

SIGNS

Shock is often severe.

LOOK — The leg usually lies externally rotated and may be short and deformed.

FEEL — Palpation is of no value.

MOVE — The patient cannot move the leg.

X-RAY — The fracture may be situated in any part of the shaft, but the middle third is the most common site. It may be spiral or transverse, or there may be a separate triangular fragment on one side.

Displacement may occur in any direction. Occasionally there are two transverse fractures, so that a segment of the femur is isolated.

EMERGENCY TREATMENT

At the site of the accident shock must be treated and the fracture must be immobilized before the patient is moved. The fractured limb may be tied to the other leg or to any convenient splint. If a Thomas splint is available, it is applied in the following manner. While steady manual traction is being maintained, the limb is threaded through the ring of the splint; the boot is then tied to the cross-piece of the splint to maintain traction, and the limb is firmly bandaged to the splint.

(A further elaboration of this technique was used for compound fractures by mobile surgical teams in the second world war. The wound was excised, traction and a Thomas splint applied, and the limb, together with the splint, encased in plaster. This "Tobruk" plaster was split and the patient could then be comfortably and safely transported.)

TREATMENT BY FIXED TRACTION ON A THOMAS SPLINT

REDUCE — The patient is anaesthetized and manual traction applied by an assistant. The skin is shaved and strapping extension applied. A Thomas splint of the correct size is threaded over the limb until the ring abuts against the ischial tuberosity. Flannel slings are passed under the limb and secured to the side-bars with safety pins. An attempt is now made to reduce the fracture by manipulation and traction. The traction tapes are pulled tight and tied to the cross-piece of the Thomas splint. Pads are arranged in front of the flannel slings to maintain the normal forward bow of the femur.

HOLD — The fixed traction is maintained and tightened as necessary. The slings and pads may also need adjustment. X-ray films are taken to ensure that reduction is maintained and traction is not excessive.

To avoid undue pressure by the ring of the splint against the ischial tuberosity, the splint is slung from an overhead beam or tied to the foot of the bed which is raised on blocks.

In adults union may be expected to take 6 weeks for a spiral fracture and 12 weeks for a transverse fracture; consolidation takes twice as long. Once union is fairly well

JOINT STIFFNESS — Stiffness of the knee is the commonest complication of a fractured femoral shaft. If the muscles have been exercised, knee movement is likely to return with use even after prolonged splintage. When balanced traction is used, there is no problem in regaining knee movement. After an infected fracture, considerable knee stiffness is almost inevitable, and if it is disabling a late quadriceps-plasty may be used.

THE KNEE

SUPRACONDYLAR FRACTURE

MECHANISM

This injury is rare and is confined to adults. A direct injury may fracture the femur above the condyles, and the lower fragment may be tilted backwards by the pull of the gastrocnemius muscle.

SIGNS

LOOK — The knee is considerably swollen and deformed.

FEEL — It is important to palpate the anterior and posterior tibial pulses for, if the femoral fragment is tilted backwards, it may obstruct the popliteal artery.

MOVE — Movement is too painful to be attempted.

X-RAY — The fracture is an inch or two above the femoral condyles and is transverse. There may be little displacement, or the fragment may be considerably tilted backwards.

TREATMENT

REDUCE — If there is no displacement reduction is unnecessary. With displacement, reduction is important and with popliteal obstruction it is urgent.

Technique — (1) A Steinmann or Denham pin is inserted behind the tibial tubercle. Strong traction is applied by an assistant while the surgeon firmly pushes the fragment into place.

(2) If closed reduction fails, and the circulation is not restored, the fracture is exposed from its lateral aspect, reduced, and held by means of an oblique screw or a small flexible intramedullary nail.

HOLD — The patient is returned to bed and 20 pounds' traction is maintained with the knee 20 degrees flexed. The limb is cradled on pillows or on a bent Thomas splint with a pad behind the knee. It is important that the direction of traction should be in the line of the tibia, not that of the femur.

The fracture takes about 12 weeks to unite and traction must be maintained during that time. The patient is then fitted with a caliper and allowed to take weight. After a further 12 weeks consolidation is usually complete and the caliper may be discarded.

EXERCISE — Quadriceps muscle exercises are encouraged, but knee movements are not permitted until the fracture has united. Then the caliper is removed and active knee movements practised.

COMPLICATIONS

SKIN DAMAGE — Skin damage is common and wound excision is then necessary.

ARTERIAL DAMAGE — Arterial damage occasionally occurs, and there is danger of gangrene.

knee and foot may be applied, so that the patient can get about until the fracture consolidates. Knee stiffness does not develop in children.

TREATMENT BY INTERNAL FIXATION

There are no absolute indications for operative fixation. It may be expedient to operate on fractures in the upper third of the shaft, and on transverse fractures near the mid-shaft, especially if (*a*) closed reduction has failed; (*b*) treatment of the soft tissues is likely to prove difficult because the patient is elderly or because there is also a fractured tibia; or (*c*) time is too precious (to a young man whose livelihood is at stake or to an elderly patient who has fractured through a secondary deposit).

REDUCE — The patient lies on the uninjured side. Through a lateral approach the fracture is exposed and the bone ends cleaned.

HOLD — Much the most efficient method of holding the reduction is by an intramedullary (Küntscher) nail which is introduced as follows.

(1) Long drills are driven upwards and downwards from the fracture to make sure that the medulla is wide enough for the proposed nail (which must fit snugly).

(2) A long guide is pushed up the proximal fragment until, with the hip flexed and adducted, it emerges in the buttock.

(3) A nail of appropriate length (measured on the other leg before operation) is threaded over the guide and hammered down until it emerges at the fracture.

(4) The guide is withdrawn and reinserted down the nail from the upper end; while the fracture is held reduced the guide is pushed into the distal fragment. The nail is then hammered home and the guide withdrawn.

EXERCISE — Immediately after operation, exercises to all the leg joints are begun. Within a fortnight the patient should have good muscle control of the limb and good movement of the hip and knee joints. He is then allowed up with crutches, but weight bearing is *delayed until the splintage afforded by the nail is reinforced by callus visible on x-ray.* Alternatively, the patient may be given a plaster hip spica, which is worn for 6–8 weeks and in which weight may be taken immediately

COMPLICATIONS

SKIN DAMAGE — The fracture may be compound and the wound then requires excision. Internal fixation should not be used for a compound fracture.

BONE COMPLICATIONS

Delayed union — Delayed union is inevitable with compound fractures and occurs if excessive traction has been used with a transverse fracture. It is essential to ensure that traction is never excessive and to exercise the longitudinal muscles around the fracture repeatedly.

Non-union — There is a danger that with delayed union splintage may be discarded too soon The fracture then angulates and may proceed to non-union. Once non-union is established, the fracture needs operation: the bone ends are freshened, a Kuntscher nail is inserted and cancellous bone chip grafts are packed round the fracture. A plaster hip spica is worn until the fracture has consolidated.

Mal-union — Mal-union is of little importance unless there is much shortening, and usually even with shortening the only treatment necessary is a raised shoe.

SIGNS

LOOK — The knee is swollen and deformed.

FEEL — The pulses in the foot should be palpated because, with forward displacement of the epiphysis, the popliteal artery may be obstructed by the lower femur.

MOVE — Movement should not be attempted.

X-RAY — The abduction injury shifts and tilts the epiphysis laterally; the hyperextension injury shifts and tilts it forwards. In either case, a triangular fragment of the shaft is displaced with the epiphysis.

TREATMENT

REDUCE — Lateral displacement is corrected by pulling on the straight leg and forcing the knee into adduction. Forward displacement is corrected by pulling with the knee bent and thumbing the fragment forwards.

HOLD — Plaster is applied from the groin to the malleoli, with the knee at 180 degrees if there was lateral displacement, and at 120 degrees if there was forward displacement. The plaster is worn for 6 weeks.

EXERCISE — Weight bearing is permitted as soon as the patient can lift his leg. Movement quickly returns when the plaster is removed.

COMPLICATIONS

There is danger of gangrene unless the hyperextension injury is reduced without delay. Interference with growth because of damage to the growth disc is rare.

FRACTURED LATERAL TIBIAL CONDYLE (BUMPER FRACTURE)

MECHANISM

The term "bumper fracture" was originally coined because the injury was thought to be caused by the impact of the bumper of a car. This is rarely the case. The injury is a valgus crush. The patient, nearly always aged 50–60 years, falls with the knee extended and slightly valgus. The lateral tibial condyle is driven upwards and smashed by the lateral femoral condyle, which itself remains intact.

SIGNS

LOOK — The knee is swollen and may be valgus.

FEEL — The swollen knee feels tender and "doughy" because of haemarthrosis.

MOVE — Usually the patient cannot lift the leg or bend it.

X-RAY — Any of the following may be seen: (*a*) a vertical split of the lateral tibial condyle without displacement; (*b*) a comminuted crush of the lateral condyle with depression of the fragments; (*c*) an oblique fracture running downwards and outwards from the tibial plateau; the tibial condyle may be tilted and the upper fibula fractured; or (*d*) sometimes a transverse line also extends across the upper tibia.

TREATMENT BY TRACTION

Treatment by traction is simple and effective and produces uniformly good results. Its sole disadvantage is that the patient must remain in hospital.

KNEE STIFFNESS — Knee stiffness is almost inevitable. A long period of exercises is necessary but full movement is rarely regained.

NON-UNION — Non-union may be associated with knee stiffness and indeed may be due to forcing knee movement too soon. The fracture is a difficult one to treat and, unless great care is exercised, the ultimate range of movement at the knee may be less than that at the fracture.

FEMORAL CONDYLE FRACTURES

MECHANISM

A direct injury or a fall may drive the tibia upwards into the intercondylar fossa. One femoral condyle may be fractured and driven upwards or both condyles split apart.

SIGNS

LOOK — The knee is swollen and may be deformed.

FEEL — There is a tender "doughy" feel characteristic of haemarthrosis.

MOVE — The knee is too painful to move, but the foot should be examined to exclude nerve damage.

X-RAY — One femoral condyle may be fractured obliquely and shifted upwards, or both condyles may be split apart so that the fracture line is T-shaped or Y-shaped.

TREATMENT

Under anaesthetic the haemarthrosis is aspirated.

REDUCE — A skeletal pin is inserted behind the tibial tubercle With strong traction and manual compression the fracture can usually be reduced. Only in young people, if closed reduction has failed, is operation advisable. The fracture is then held with screws.

HOLD — The leg is cradled on pillows and 15 pounds' traction maintained for 6 weeks; by this time the fracture has usually united. The patient is then allowed up using crutches, but must not take weight until consolidation is complete, which usually takes 3 months.

EXERCISE — Quadriceps muscle exercises are vigorously practised from the start. Knee flexion is also encouraged and is facilitated by using a divided mattress; the distal half of the mattress is removed at intervals and active knee movements practised repeatedly without removing the traction. Movement often improves a previously imperfect reduction because the smashed femoral condyles are "*moulded*" *by the intact tibia.*

FRACTURE-SEPARATION OF LOWER FEMORAL EPIPHYSIS

MECHANISM

In an adolescent the lower femoral epiphysis may be displaced (*a*) laterally by forced abduction of the straight knee, as when as opponent falls on a player in a rugger scrum; or (*b*) forwards by a hyperextension injury.

TREATMENT

REDUCE — Under anaesthesia the joint is aspirated; it is then fully straightened and the fracture thereby reduced.

Sometimes the true nature of the injury is not immediately realized and after a few weeks it may be impossible to straighten the knee even under anaesthesia. Operative reduction is then essential; the tibial spine is anchored by sutures into a cavity gouged out of the upper tibia.

HOLD — A plaster tube is applied from the groin to the malleoli with the knee at 180 degrees and is worn for 6 weeks.

EXERCISE — Weight bearing is permitted and the quadriceps muscle vigorously exercised. When the plaster is removed, knee flexion is regained by active use.

INJURIES OF UPPER TIBIAL EPIPHYSIS

MECHANISM

In a child, resisted extension of the knee usually causes a strain at the insertion of the extensor mechanism into the tibial tubercle (Osgood-Schlatter's disease: *see* page 221). Occasionally the ligament remains intact but its attachment is avulsed.

SIGNS

LOOK — The knee is held flexed and may be swollen.

FEEL — The front of the upper tibia is tender.

MOVE — The knee cannot be actively extended.

X-RAY — The entire upper tibial epiphysis may be tilted forwards. Sometimes, when the ligament is attached to a small apophysis separate from the main epiphysis, this apophysis is avulsed and shifted upwards.

TREATMENT

REDUCE — Under anaesthesia the knee is pushed straight, and x-rays then usually show that reduction has been achieved. If the small separate apophysis remains displaced it is operatively reduced and sutured in position. Occasionally, when the entire tibial epiphysis cannot be accurately reduced by closed manipulation, it is replaced at operation and held by a screw.

HOLD — Following reduction, whether closed or open, a plaster tube is applied from the groin to the malleoli with the knee at 180 degrees. It is worn for 6 weeks.

EXERCISE — Weight bearing is permitted at once and quadriceps exercises practised. Knee flexion quickly returns when the plaster is removed.

FRACTURED PATELLA

DIRECT (STELLATE) FRACTURE

MECHANISM

A fall or a direct blow may smash the patella against the femur. The expansions on each side of the patella usually remain intact.

REDUCE — If there is much haemarthrosis the joint is aspirated. A Steinmann or Denham pin is inserted through the tibia 2 inches below the fracture. Traction is applied and the condyle manually pushed back into place.

HOLD — The leg is cradled on pillows and 10 pounds' traction maintained until the fracture is united, at about 6 weeks. The pin is then removed and the patient is allowed up using crutches. Full weight bearing should be deferred for a further 6 weeks.

EXERCISE — Quadriceps muscle exercises are vigorously practised from the very beginning. As soon as the patient can lift his leg, knee flexion is permitted while the traction is maintained. There should be fully controlled extension with flexion to 90 degrees within 4 weeks. Movements often improve a previously imperfect reduction.

TREATMENT IN PLASTER

Treatment in plaster also gives good results, though knee movement takes longer to return; it has the advantage that the patient need not remain in hospital for long.

REDUCE — The fracture is reduced by strong traction and lateral compression.

HOLD — Plaster is applied from groin to malleoli with the knee straight. It is removed after 6–12 weeks according to the severity of the injury, and weight bearing is then permitted.

EXERCISE — Quadriceps muscle exercises are practised within the plaster and knee movement is regained when the plaster is removed.

OPERATIVE TREATMENT

If closed reduction fails, and especially if the condyle is much displaced without comminution, open reduction and levering the condyle back into place has been advocated; at operation the condyle may be fixed by means of screws. There is no convincing evidence that the results of operative treatment are better than those of either of the above methods.

COMPLICATIONS

Slight valgus deformity may persist but, even so, function is usually very good and late osteoarthritis surprisingly rare. Failure to regain full knee bend is the only important cause of disability, and is avoided by early movements.

FRACTURED TIBIAL SPINE

MECHANISM

A hyperextension injury or a fall on the bent knee may tear the anterior cruciate ligament (*see* page 215); sometimes the ligament remains intact but instead the tibial spine is avulsed.

SIGNS

LOOK — The knee is held flexed and is swollen.

FEEL — Because of haemarthrosis the joint feels tense, tender and "doughy".

MOVE — Movement is too painful to be attempted.

X-RAY — A lateral film shows the anterior tibial spine elevated from the tibia.

SIGNS

LOOK — There is gross deformity.

FEEL — The circulation in the foot must be examined because the popliteal artery may be obstructed.

MOVE — The patient is asked to move the foot so that possible injury to the lateral popliteal nerve may be detected.

X-RAY — In addition to the dislocation, the films occasionally show a fracture of the tibial spine (cruciate ligament avulsion) or of the tip of the fibula (lateral ligament avulsion).

TREATMENT

REDUCE — Reduction (by manipulation) is urgent. Occasionally closed reduction fails because the torn medial ligament lies between the femur and the tibial condyles; open reduction must then be performed and the ligament is sutured back into place.

HOLD — Plaster is applied from the groin to the malleoli with the knee at 160 degrees. The plaster is split. When swelling has subsided, a new plaster is applied and is worn for 12 weeks from the injury.

EXERCISE — Quadriceps muscle exercises are practised from the start. Weight bearing in the plaster is permitted as soon as the patient can lift his leg. Knee movements are regained when the plaster is removed.

COMPLICATIONS

ARTERIAL DAMAGE — Arterial damage may cause gangrene.

NERVE INJURY — Nerve injury, especially to the lateral popliteal nerve, may occur but usually recovers.

JOINT INSTABILITY — Joint instability (increased antero-posterior glide or lateral wobble) usually remains but, providing the quadriceps muscle is sufficiently powerful, the disability is not severe.

DISLOCATION OF THE PATELLA

MECHANISM

While the knee is flexed and the quadriceps muscle relaxed, the patella may be forced laterally by direct violence. It may perch temporarily on the ridge of the lateral femoral condyle and then either slip back into position or be displaced to the outer side, where it lies with its anterior surface facing laterally.

SIGNS

LOOK — There is obvious deformity. The displaced patella may not be easily noticed but the uncovered medial femoral condyle is unduly prominent.

FEEL — The patella can be felt on the outer side of the knee.

MOVE — Neither active nor passive movement is possible.

X-RAY — The patella is seen to be laterally displaced and rotated.

TREATMENT

REDUCE — The patella is easily pushed back into place, and anaesthesia is not always necessary.

SIGNS

LOOK — The knee is swollen and held flexed.
FEEL — There is tenderness, and blood in the knee joint.
MOVE — The patient is sometimes able to lift the straight leg.
X-RAY — The films may show (*a*) one or more fine fracture lines without displacement (the appearance is not to be confused with a bipartite patella in which a smooth line extends obliquely across the superolateral angle of the bone); or (*b*) multiple fracture lines with irregular displacement.

TREATMENT

ACTIVITY — If there is no displacement, the fracture need not be reduced or held. A tense effusion should be aspirated. It is wise to apply a plaster back slab with the knee at 180 degrees, and to wear it until quadriceps muscle control is regained. The slab is removed several times a day for active exercises.

PATELLECTOMY — If the fragments are displaced reduction is impossible. It is better to excise the patella without delay, for degenerative changes are otherwise inevitable.

INDIRECT (TRANSVERSE) FRACTURE

MECHANISM

Resisted extension of the knee may rupture the extensor mechanism. Typically the patient catches his foot and, to avoid falling, contracts the quadriceps muscle; but the stair or other obstacle prevents straightening of the knee. In middle life this injury usually fractures the patella transversely and tears the lateral extensor expansions.

SIGNS

LOOK — The knee is swollen and held flexed.
FEEL — At first a gap is palpable, but later it fills with blood.
MOVE — The patient is unable to lift the straight leg.
X-RAY — The patella is fractured transversely; there is a gap between the two halves and the upper fragment is shifted proximally.

TREATMENT

Operation is essential Unless the extensor mechanism is repaired, the last 10 or 20 degrees of active extension will be lost and the knee will be unstable.

TECHNIQUE — Through a transverse incision the fracture and the lateral expansions of the quadriceps muscle are exposed. The expansions are repaired with strong catgut sutures. It may be convenient to wire or screw the two halves of the patella together but, unless the articular surface is perfectly reduced and smooth, it is better to excise the patella and repair the deficiency.

DISLOCATION OF THE KNEE

MECHANISM

The knee can only be dislocated by considerable violence, as in a road accident. The cruciate ligaments and one or both lateral ligaments are torn.

MOVE — Knee and ankle movements are possible, and a child with a spiral fracture may be able to stand.

X-RAY — A spiral fracture in a child may be almost invisible in the antero-posterior view and, unless a lateral film is also taken, the injury may at first be undiagnosed; after a few days the fracture line is more obvious, and callus can be seen.

Transverse and slightly oblique fractures are easily seen by x-ray. Displacement is slight, usually consisting only of a little lateral shift or angulation.

CLOSED TREATMENT

REDUCE — Under anaesthesia it is easy to reduce the slight angulation of a short oblique fracture, but it is sometimes impossible to correct the slight lateral shift of a transverse fracture.

HOLD — Plaster is applied, extending from the groin to the toes with the knee at an angle of 175 degrees and the foot plantigrade. It is wise to split the plaster and to complete or replace it in a few days when swelling has subsided.

A spiral fracture in a child needs only 6 weeks in plaster. Transverse and short oblique fractures in adults take about 12 weeks to unite and 24 weeks to consolidate. The complete above-knee plaster is certainly necessary for the first 12 weeks and is probably best retained until consolidation is complete. If the fracture is in the mid-shaft and the surgeon highly skilled in the use of plaster, it is probably safe to apply a plaster gaiter from the knee to the ankle for the second 12 weeks.

EXERCISE — The patient is allowed to take weight as soon as the complete plaster has been applied. He is fitted with an overboot which has a rockered sole, and he is taught to walk correctly with a heel-toe gait. When the plaster is removed, a crêpe bandage is applied and the patient instructed not to dangle the leg but to elevate and exercise it, or to walk normally on it.

OPERATIVE TREATMENT

Operative reduction and fixation has been advocated. Its only advantage is that it permits accurate reduction which probably hastens union a little. Operation is never essential, and plaster for a prolonged period is still necessary. With an oblique fracture, one or two screws may be inserted and with a transverse fracture a plate and screws are used. In children, operative treatment is never used.

COMPLICATIONS

The fracture may be compound and require wound excision. Union then is slower and great care must be taken not to discard splintage too early. Ankle and foot stiffness are common but are minimized by walking correctly in plaster.

FRACTURED TIBIA AND FIBULA

SPIRAL FRACTURE

MECHANISM

A twisting force applied to the foot may cause a spiral fracture of both bones. The tibia may puncture the skin.

HOLD — With the knee at 180 degrees, a plaster back slab is applied. It is worn for 3 weeks.

EXERCISE — Quadriceps muscle exercises are begun at once and practised assiduously. As soon as the patient can elevate his leg, walking is allowed. When the back slab has been removed, flexion is easily regained.

COMPLICATIONS

Recurrent dislocation may occur, especially if the quadriceps muscle has not been redeveloped (*see* page 222).

THE LEG

FRACTURED SHAFT OF FIBULA

MECHANISM

A direct blow in an adult may break the fibula transversely. Fractures of the lower fibula are commonly associated with ankle injuries and are considered under that heading. Occasionally a stress fracture occurs near the lower end.

SIGNS

LOOK — A bruise and local swelling are visible.

FEEL — The fracture site is tender.

MOVE — The patient can stand and can move his knee and ankle.

X-RAY — A transverse fracture is seen, but displacement is slight because the tibia is intact. It is important (especially if the patient cannot walk) to x-ray the entire leg because the tibia may have fractured at another level.

If an oblique fracture of the upper fibula is seen the ankle should also be examined, for there may be an external rotation Pott's fracture (*see* page 350).

TREATMENT

REDUCE — No reduction is necessary.

HOLD — No splintage is required. A crêpe bandage is comforting.

EXERCISE — The patient walks as soon as he is comfortable.

FRACTURED SHAFT OF TIBIA

MECHANISM

In children a twisting force may cause a spiral fracture of the tibia without a fractured fibula; this is rare in adults.

At any age a direct injury, such as a kick at football, may cause a transverse or slightly oblique fracture of the tibia at the site of impact.

SIGNS

LOOK — In a transverse fracture skin is often damaged. There may be bruising, swelling and slight deformity.

FEEL — There is localized tenderness.

COMPLICATIONS

The fracture may be compound. Mal-union with overlap and shortening are liable to occur if weight is taken too soon; it rarely troubles the patient.

TRANSVERSE FRACTURE

MECHANISM

A direct injury crushes the skin and fractures both bones at the same level. An angulation force also breaks both bones at the same level, usually the mid-shaft, and the tibia often pierces the skin. Motorcycle accidents are the commonest cause.

SIGNS

LOOK — The skin may be undamaged or obviously divided; sometimes it is intact but has been crushed, and there is danger that it may slough within a few days, and the fracture become compound.

FEEL — The pulses in the foot are palpated to assess the circulation.

MOVE — Movement should not be attempted.

X-RAY — Both bones are broken transversely at the same level and there may be shift, tilt or twist in any direction.

CLOSED TREATMENT

When the fracture is compound it is treated by closed methods, even though preliminary wound excision has been necessary. In adults, when the skin is undamaged, there is a choice between closed and operative treatment (*see* page 346). When the skin viability is in doubt, Perkins advises a period of provisional treatment with the leg on skeletal traction.

REDUCE — Reduction is effected by traction and manipulation, preferably with a skeletal pin through the os calcis or the lower tibia. The bone ends should first be accurately apposed, then the alignment should be corrected. The appearance of the injured leg should be the same as that of the uninjured leg when seen from the front or from the side and care must be taken to avoid torsional deformity.

HOLD — A padded plaster is applied, extending from the groin to the toes, as for a spiral fracture. The plaster is split. X-ray films are then taken to confirm reduction and, if necessary, the plaster is wedged to correct angulation. The pin is removed and the patient returned to bed with the leg elevated. When swelling has subsided a complete plaster is applied and reduction again confirmed by x-ray.

The fracture takes at least 12 weeks to unite and 24 weeks to consolidate. The full-length plaster must be worn until consolidation is clinically and radiologically complete. A transverse fracture in which the ends are accurately apposed differs from a spiral fracture in being stable to compression; hence, provided the plaster prevents angulation, weight bearing is safe and is encouraged.

EXERCISE — The patient is fitted with an overboot which has a rockered sole, and is taught to walk with a normal heel-toe gait. When the plaster is removed and consolidation is complete, a crêpe bandage is applied and the patient is taught to exercise the limb and to walk normally. He must not let it dangle idly and, until circulatory control has been regained, he should elevate the injured leg on another chair when sitting.

SIGNS

LOOK — The foot is usually rolled outwards and deformity is obvious.

FEEL — Palpation is of no value.

MOVE — Movements should not be attempted.

X-RAY — The tibial fracture is spiral, usually in the lower third of the shaft. The fibular fracture also is spiral and usually at a higher level. There is lateral shift, overlap and outward twist below the fracture.

CLOSED TREATMENT

REDUCE — The patient is anaesthetized. Traction is applied to the foot and the foot is twisted inwards. It may be possible to apply sufficient force manually, but it is much simpler to use skeletal traction, by a pin driven through the os calcis or the lower tibia.

HOLD — (1) An assistant maintains traction and internal rotation while the surgeon applies plaster extending from the upper thigh to the toes with the knee at an angle of 170 degrees and the foot plantigrade. It may facilitate the application of plaster if the knee is bent over the end of the table and the plaster applied in two sections, first below the knee, then above it The anterior third of the plaster is removed.

(2) The most certain way of maintaining reduction and preventing overlap is by continuous traction. A weight of 10 pounds is attached to the pin and the leg is cradled on pillows After 6 weeks, the pin is removed and a complete above-knee plaster is applied with the knee at an angle of 170 degrees and the foot plantigrade.

(3) Slight overlap causes only trivial disability and, if the patient is unwilling to spend 6 weeks in hospital, the Steinmann pin may be removed as soon as the plaster has set. When the swelling has subsided, a complete above-knee plaster is applied and the patient may get up, but he must not bear weight for the first 6 weeks.

(4) After 6 weeks, with any of these methods, the fracture has usually united, but a further 6 weeks in an above-knee plaster is necessary for consolidation. The patient may take increasing weight. At 12 weeks the plaster is removed and, if there is clinical and radiological evidence of consolidation, the plaster is replaced by a temporary crêpe bandage.

EXERCISE — The *patient is taught to exercise the muscles of the foot, ankle and knee* repeatedly from the very beginning. When he gets up, an overboot with a rockered sole is fitted, and he is taught to walk correctly, even if weight is not being taken, he must go through the motions of correct walking. When the plaster is removed, a crêpe bandage is applied and the patient instructed to elevate and exercise the limb or to walk correctly on it, but not to let it dangle idly.

OPERATIVE TREATMENT

Operation is never essential In adults, however, if the fracture is openly reduced and the tibia fixed by one or two screws, or by a plate and screws, it is much more stable. As soon as the wound has healed and plaster has been applied from groin to toes, weight may safely be taken. The patient spends less time in hospital or on crutches, but the fracture takes just as long to consolidate.

THE ANKLE

SPRAINS AND DISLOCATIONS

MECHANISM

The patient falls or stumbles and the foot inverts under him. As a rule, there is only a partial tear of the lateral ligament and the injury is an ankle sprain. Sometimes, however, the ligament is completely torn, and the joint dislocates; the dislocation is only momentary. (The term "dislocation" is not strictly accurate, for the talus has subluxated rather than dislocated.) True dislocation with the talus completely out of its socket is very rare, and does not reduce spontaneously (*see* page 353).

SIGNS

LOOK — The ankle is swollen.

FEEL — Tenderness is usually maximal on the outer aspect of the joint.

MOVE — Inversion is painful, but only with a complete tear of the ligament is the movement excessive. Pain may prevent excessive movement from being demonstrated and, if the injury is severe, inversion must be tested again under local or general anaesthesia.

X-RAY — The x-ray appearance of the resting ankle is normal whether the joint has been sprained or dislocated, for a dislocation reduces itself. X-ray films taken with both ankles inverted (if necessary using local or general anaesthesia) will show whether the talus tilts unduly on the affected side.

TREATMENT

SPRAIN — An ankle sprain should be treated by activity. A crêpe bandage is applied and active exercises are begun immediately and persevered with until full movement is regained The patient is not allowed to dangle the leg and the bandage is worn until swelling has disappeared. Weight may be taken as soon as the patient will walk, but he must be taught to walk correctly with the normal heel-toe gait.

DISLOCATION — A dislocation must be treated in plaster. No reduction is necessary. Plaster is applied from just below the knee to the toes, with the foot plantigrade. If there is swelling, the plaster is split and replaced when the swelling has subsided. Plaster is worn until the ligament may be expected to have repaired, which takes about 10 weeks. The patient is encouraged to walk normally with the aid of an overboot with a rockered sole. When plaster is removed, a crêpe bandage is worn and movements are regained by active use.

COMPLICATIONS

ADHESIONS — Following an ankle sprain, adhesions are liable to form unless the foot is actively and correctly used. The patient complains that the ankle "gives way" and lets him down. Following such an incident, there is tenderness on the outer side and pain on inversion, but no excessive inversion. If active exercises fail to restore full painless movement, the joint should be manipulated under anaesthesia and full range maintained by activity.

RECURRENT DISLOCATION —If a complete tear of the lateral ligament was undiagnosed, and consequently unsplinted, the ligament fails to repair and dislocation becomes

OPERATIVE TREATMENT

Operative fixation is never essential but, if the surgeon is certain that the skin is quite undamaged and he can rely completely on the aseptic technique of his team, he may prefer operative treatment. The tibia is exposed on its subcutaneous surface and the fracture ends are meticulously cleaned and fitted together (they must fit perfectly). A long and strong plate is then fixed to the bone by screws which penetrate the opposite cortex.

It is unsafe to walk on the leg unless it is protected by plaster. The usual method is to apply a full above-knee plaster from the time of operation, but "delayed splintage" is better: after operation, an above-knee plaster is applied, but its anterior half is removed. Twice a day the leg is lifted out of the plaster for supervised exercises to restore knee, ankle and foot movements. After 2–3 weeks, when the wound has healed, a complete above-knee plaster is applied and worn until the fracture has consolidated. Full weight may be taken. Movements, having once been regained, will return rapidly when the plaster is removed.

COMPLICATIONS

SKIN DAMAGE — Skin damage is common. It is important, after wound excision, to close the skin over the tibia; in order to avoid tension, relieving incisions may be necessary elsewhere in the calf. If the wound becomes infected union is considerably delayed, and splintage must not be discarded too early. Skin grafting or sequestrectomy is sometimes necessary.

ARTERIAL DAMAGE — Arterial damage is uncommon, but Volkmann's ischaemia may occur; because it is less common in the leg than in the forearm, it is less likely to be diagnosed (*see* page 267).

MAL-UNION — Mal-union is common. Rotation and angulation deformity are not only ugly but are disabling, because the knee and ankle no longer move in the same plane. If severe deformity has not been prevented, it should be corrected by osteotomy.

Backward angulation is common and, if it is accompanied by a stiff equinus ankle, it is dangerous, for when the patient tries to force the foot up in walking the tibia is liable to refracture. This may occur insidiously and lead to *non-union*.

NON-UNION — Non-union is usually the result of faulty treatment. Contributory factors are infection, excessive traction and a stiff equinus ankle (*see* above). It is important to recognize delayed union and to *maintain splintage until consolidation is complete*.

Once non-union is established the patient must either wear a permanent splint or the fracture must be operated upon. The bone ends are freshened, fixed with a cortical bone graft and packed with cancellous bone chips. An inch of fibula is excised and the fracture is then treated in plaster.

JOINT STIFFNESS — Joint stiffness is often due to neglect in treatment of the soft tissues; [illegible]

manipulation under anaesthesia is often helpful.

Talus — If there is talar shift (sideways, upwards or forwards), or tilt or widening of the mortise, subluxation is present. Usually there is an accompanying mortise fracture and the injury is called a fracture-subluxation or fracture-dislocation. Very occasionally the mortise may be widened without accompanying fracture, because the ligaments have been extensively torn, but the injury is still a subluxation. Formerly, ankle fractures were classified according to the position of the talus in its mortise; the only value of this classification lay in drawing attention to the importance of the position of the talus.

The mortise — (*a*) An external rotation force causes a spiral fracture of the fibula. With continuing force, the medial malleolus may be avulsed and fractured transversely. Further rotation may lead to avulsion of a posterior fragment of the tibia, to which the tibiofibular ligament is attached.

(*b*) An abduction force fractures the fibula transversely 2 inches above the joint and may avulse the tip of the medial malleolus. The tibiofibular ligament may also be torn, with or without avulsion of its tibial attachment; the ligament tear allows the tibia and fibula to separate and the talus to be driven up between them (diastasis).

(*c*) An adduction force causes a near-vertical fracture of the medial malleolus extending upwards from the medial angle of the mortise; the tip of the fibula may also be avulsed.

(*d*) A shearing force (which is uncommon) fractures both malleoli transversely at the level of the lower surface of the tibia.

(*e*) An upward thrust may split the tibia vertically and this vertical fracture often joins a transverse fracture 2–3 inches above the joint. Sometimes a vertical force shears off the anterior or posterior corner of the lower tibia.

In adolescents, similar injuries may occur and cause fracture-separation of the lower tibial epiphysis.

CLOSED TREATMENT

REDUCE — If there is displacement, it must be accurately reduced by manipulation under anaesthesia. First manual traction is applied, then a force is applied the reverse of that which caused the injury. Unless the causal force has been correctly deduced from the x-ray films, and has been reversed by manipulation, accurate reduction is unlikely.

HOLD — A padded plaster is applied from just below the knee to the toes, with the foot plantigrade; that is, with the foot at an angle of 90 degrees to the leg and neither in varus nor valgus position. (There is a tendency to apply the plaster with the foot inverted, and this must be resisted.) The plaster may need to be split and if so it must be completed or replaced when swelling has subsided. An x-ray film to confirm reduction must be taken after the plaster has been applied and another after it has been changed. With an external rotation fracture, 6 weeks in plaster is sufficient; all other fractures should be kept in plaster for 12 weeks.

Fractures with no trace of displacement clearly require no reduction and are sometimes treated without plaster, the patient being allowed to walk with the ankle in a crêpe bandage. The method is safe only when it is certain that there has not been spontaneous reduction of displacement.

EXERCISE — An overboot is fitted and the patient is taught to walk correctly as soon as possible. Ankle and foot movements are regained by active exercises when the plaster is removed. As with any lower limb fracture, the leg must not be allowed to dangle

recurrent. The history is similar to that of adhesions following a sprain; the patient, after an injury, complains that the ankle gives way at intervals. The talus, however, can be inverted further than that of the normal ankle. If the diagnosis is in doubt, the patient should be anaesthetized and both ankles x-rayed in full inversion. If the talus tilts, the injury is a dislocation; if not, the adhesions are immediately broken down by manipulation.

Treatment — Recurrent dislocation of the ankle can be treated by raising the outer side of the heel slightly and extending its lower surface laterally ("floated-out heel"). This treatment is not very effective and it is better to operate, using Watson-Jones' technique.

Technique — The peroneus brevis tendon is detached from the muscle, threaded forwards through a hole in the fibula, downwards through the talus, and back through a second hole in the fibula. Plaster is worn for 8 weeks The operation is a tenodesis and effectively replaces the damaged ligament.

RECURRENT DISLOCATION OF PERONEAL TENDONS — Adhesions and recurrent dislocation are two causes of giving way of the ankle. A third but uncommon cause is recurrent dislocation of the peroneal tendons. The condition is unmistakable, for the patient can demonstrate that the peroneal tendons dislocate forwards over the fibula in certain positions. At operation the superficial cortex of the lower 2 inches of the fibula should be hinged backwards and stitched over the peroneal tendons to hold them in their correct position.

POTT'S FRACTURE

This term is here used to include (*a*) fractures of the bones comprising the ankle mortise, namely the lower tibia and fibula; (*b*) displacement of the talus within its mortise, whether associated with fractures or not. The most important single feature of an ankle injury is whether the talus fits within the mortise accurately; it must be remembered that the talus may have been displaced at the time of injury, and yet be in position when the patient is seen in hospital.

MECHANISM

Pott's fracture occurs when the foot is anchored to the ground while the momentum of the body continues forwards; the patient may stumble over an unexpected obstacle or stair, or into a small depression in the ground, or he may have fallen from a height. The momentum of the body may impose any one of a variety of forces upon the ankle, the most important being external rotation, abduction, adduction and shearing. To these may be added an upward thrust if the patient has fallen from a height.

SIGNS

LOOK — The ankle soon becomes swollen and bruised. Deformity may be obvious.

FEEL — The site of tenderness varies with the precise nature of the injury.

MOVE — The patient cannot move his ankle.

X-RAY — From a study of the fracture pattern the precise type of fracture-dislocation can be deduced, and treatment depends upon correct identification of the injury.

Talus — If there is talar shift (sideways, upwards or forwards), or tilt or widening of the mortise, subluxation is present. Usually there is an accompanying mortise fracture and the injury is called a fracture-subluxation or fracture-dislocation. Very occasionally the mortise may be widened without accompanying fracture, because the ligaments have been extensively torn, but the injury is still a subluxation. Formerly, ankle fractures were classified according to the position of the talus in its mortise; the only value of this classification lay in drawing attention to the importance of the position of the talus.

The mortise — (*a*) An external rotation force causes a spiral fracture of the fibula. With continuing force, the medial malleolus may be avulsed and fractured transversely. Further rotation may lead to avulsion of a posterior fragment of the tibia, to which the tibiofibular ligament is attached.

(*b*) An abduction force fractures the fibula transversely 2 inches above the joint and may avulse the tip of the medial malleolus. The tibiofibular ligament may also be torn, with or without avulsion of its tibial attachment; the ligament tear allows the tibia and fibula to separate and the talus to be driven up between them (diastasis).

(*c*) An adduction force causes a near-vertical fracture of the medial malleolus extending upwards from the medial angle of the mortise; the tip of the fibula may also be avulsed.

(*d*) A shearing force (which is uncommon) fractures both malleoli transversely at the level of the lower surface of the tibia.

(*e*) An upward thrust may split the tibia vertically and this vertical fracture often joins a transverse fracture 2–3 inches above the joint. Sometimes a vertical force shears off the anterior or posterior corner of the lower tibia.

In adolescents, similar injuries may occur and cause fracture-separation of the lower tibial epiphysis.

CLOSED TREATMENT

REDUCE — If there is displacement, it must be accurately reduced by manipulation under anaesthesia. First manual traction is applied, then a force is applied the reverse of that which caused the injury. Unless the causal force has been correctly deduced from the x-ray films, and has been reversed by manipulation, accurate reduction is unlikely.

HOLD — A padded plaster is applied from just below the knee to the toes, with the foot plantigrade; that is, with the foot at an angle of 90 degrees to the leg and neither in varus nor valgus position. (There is a tendency to apply the plaster with the foot inverted, and this must be resisted.) The plaster may need to be split and if so it must be completed or replaced when swelling has subsided. An x-ray film to confirm reduction must be taken after the plaster has been applied and another after it has been changed. With an external rotation fracture, 6 weeks in plaster is sufficient; all other fractures should be kept in plaster for 12 weeks.

Fractures with no trace of displacement clearly require no reduction and are sometimes treated without plaster, the patient being allowed to walk with the ankle in a crêpe bandage. The method is safe only when it is certain that there has not been spontaneous reduction of displacement.

EXERCISE — An overboot is fitted and the patient is taught to walk correctly as soon as possible. Ankle and foot movements are regained by active exercises when the plaster is removed. As with any lower limb fracture, the leg must not be allowed to dangle

idly. It must be exercised or elevated. After removal of the plaster a temporary crêpe bandage is necessary.

OPERATIVE TREATMENT

Operative treatment may be necessary (*a*) to ensure perfect reduction; (*b*) to maintain reduction; or (*c*) to aid in the treatment of the soft tissues. When operation is undertaken, internal fixation with a screw is employed, even if the object of the operation was only to obtain perfect reduction. Internal fixation by itself is insufficient to permit of unprotected walking. After operation, movements should be regained and then a below-knee plaster worn until the fracture has consolidated.

TO REDUCE — If the talus, after closed reduction, does not fit the mortise accurately, one or other malleolus (usually the medial) is exposed. Sometimes a flap of periosteum is found interposed between the medial malleolus and the tibia, or the peroneal tendons between the lateral malleolus and the shaft of the fibula. The fracture is accurately reduced and held by internal fixation

TO HOLD REDUCTION — Both fractures with diastasis and shearing fractures are very unstable. They are most efficiently held if a screw is inserted through the medial malleolus into the tibia and, when necessary, a second screw inserted transversely from the fibula to the tibia. When a diastasis is accompanied by an oblique fibular fracture, the fibular fragments may be held together with an encircling wire.

TO TREAT SOFT TISSUES — In elderly people it may be unwise to immobilize the foot for a long period in plaster. The fracture may be fixed *internally*; *movement is regained while the* patient is in bed, and a walking plaster is then applied until the fracture is consolidated.

COMPLICATIONS

MAL-UNION — Mal-union is not uncommon and, unless the talus fits the mortise accurately, degenerative changes are liable to occur. Sometimes degeneration can be halted or prevented by a corrective osteotomy. If osteoarthritis has already developed arthrodesis may prove necessary.

Secondary mal-union from epiphyseal arrest in an adolescent is rare.

NON-UNION — Non-union of the medial malleolus occasionally occurs if a flap of periosteum is interposed between it and the tibia. It should be prevented by operative reduction and screw fixation

JOINT STIFFNESS — *Joint stiffness and swelling of the ankle are usually the result of neglect* in treatment of the soft tissues. The patient must walk correctly in plaster and, when the plaster is removed, he must, until circulatory control is regained, wear a crêpe bandage and elevate the leg whenever he is not using it actively. Occasionally, several months after the fracture, manipulation under anaesthesia may be needed to restore full movement.

THE TARSUS AND FOOT

INJURIES OF THE TALUS

MECHANISM

Talar injuries are due to considerable violence and are rare. They are usefully classified according to the direction of the causal force, as advised by Watson-Jones.

INVERSION — A fall with the foot forced into inversion and plantarflexion may cause dislocation at the subtaloid joint; the talus remains in the ankle mortise. A similar force may dislocate the talus completely so that it is out of the ankle mortise and detached from the os calcis and navicular bone.

DORSIFLEXION — A severe dorsiflexion injury, as in an air crash, may drive the neck of the talus upwards against the front of the tibia causing a vertical fracture; with more force the talus is angulated downwards or its posterior half is squeezed backwards out of position. Rarely the fracture occurs not through the neck but through the dome of the talus.

SIGNS

LOOK — The foot is obviously deformed and swollen. The skin may have been split or may rapidly necrose.
FEEL — Palpation is of little value.
MOVE — The foot is held immobile.
X-RAY — With subtaloid dislocation the talus is in the ankle mortise but points downwards; its distal end is not in contact with the navicular bone. With talar dislocation the bone is completely outside the mortise, is displaced forwards and rotated.

With talar fractures a vertical fracture through the neck is seen in the lateral film, and it is important to recognize displacement; the two halves of the bone may be angulated, or the posterior half may be subluxed backwards at the subtaloid joint or dislocated out of the ankle mortise.

TREATMENT

SUBTALOID DISLOCATION — Reduction is readily effected by pulling the foot strongly into plantarflexion. A plaster back slab is applied and is worn for a few days. Active exercises are then started and the patient may walk with the leg supported in a crêpe bandage.

TALAR DISLOCATION — Reduction is urgent because the stretched skin may necrose. The foot is pulled strongly into plantarflexion and inversion, and the talus thumbed back into place. A widely split below-knee plaster is applied with the foot plantigrade and is worn for 6 weeks. Active exercises are encouraged when the plaster has been removed, and weight bearing is then permitted if the talus is not unduly dense on x-ray.

TALAR FRACTURES — With fractures of the neck of the talus even slight angulation must be corrected by forced plantarflexion of the foot. With posterior shift of the back half of the bone reduction is urgent. If plantarflexion alone proves ineffective, a Steinmann pin is inserted through the os calcis, which is pulled strongly away from the tibia while the talus is transfixed by a second Steinmann pin and pushed into position.

A widely split below-knee plaster is applied with the foot fully plantarflexed (an unfamiliar and unpleasant position which is here essential). Three weeks later, without anaesthesia, the plaster is removed and the patient is persuaded to dorsiflex his foot gently; a complete below-knee plaster is then applied with the foot plantigrade and this is worn for a further 6 weeks.

When the plaster is removed the patient is encouraged to practise active exercises.

Weight bearing is avoided until x-rays show that the talus has not undergone avascular necrosis.

A fracture of the dome of the talus usually cannot be reduced. If a loose fragment of bone is lying in the joint it should be removed. When the bone is split or comminuted it is best to mould the fragments into position by active movements, but weight bearing is deferred for at least 12 weeks.

COMPLICATIONS

SKIN DAMAGE — Skin damage is common either because the skin has been split or because it is tightly stretched and necroses Even when a totally detached talus is lying in the wound the bone should not be excised but replaced.

AVASCULAR NECROSIS — Avascular necrosis of part or all of the talus may occur. The bone becomes dense on x-ray, but it should be remembered that in the lateral view the overlying malleoli normally cause a dense appearance. An avascular talus crushes with weight bearing: degenerative changes are then inevitable and the ankle may need to be arthrodesed.

FRACTURES OF THE OS CALCIS

MECHANISM

The patient usually falls from a height, often from a ladder, onto one or both heels. The os calcis is driven up into the talus and may be split or crushed. The same accident may also have damaged the spine, which must always be examined in os calcis injuries.

SIGNS

LOOK — The heel is broad and a D-shaped bruise appears in the sole.

FEEL — The heel is thick and tender and the normal concavity below the lateral malleolus is lacking.

MOVE — The subtaloid joint cannot be moved but ankle movement is possible.

X-RAY — Unless every patient with a painful heel after a fall is x-rayed, fractures of the os calcis may remain undiagnosed Lateral and axial films are required. (An axial film is one taken with the x-rays passing obliquely through the sagittal plane of the bone.)

Os calcis fractures are classified as isolated, split, or crush fractures.

Isolated fractures — These comprise (*a*) vertical fracture of the medial tuberosity; (*b*) horizontal fracture of the postero-superior corner of the os calcis, sometimes with upward tilt; and (*c*) fracture of the antero-superior corner of the os calcis obliquely into the calcaneocuboid joint. All these are rare.

Split fractures — The os calcis is split into two segments by a vertical fracture which extends from the medial aspect near the back of the os calcis to the lateral aspect in front. The larger lateral segment is usually shifted laterally and the smaller medial segment displaced upwards. The fracture usually extends into the subtaloid joint but the joint may not be severely damaged.

Crush fractures — The fracture line or lines resemble those of split fractures but the

portion of the os calcis which articulates with the talus is driven downwards into the body of the bone. The subtaloid joint is grossly damaged and occasionally the calcaneocuboid joint is also affected.

TREATMENT OF ISOLATED FRACTURES

If there is no displacement, neither reduction nor splintage is necessary. A crêpe bandage is applied and the patient encouraged to walk.

If there is displacement it is reduced by manipulation under anaesthesia. A below-knee plaster is applied with the foot plantigrade (except when a horizontal fracture can be held reduced only with the foot plantarflexed). An overboot is fitted and the patient is taught to walk. After 6 weeks the plaster is removed, a crêpe bandage is applied and full active use encouraged.

TREATMENT OF SPLIT FRACTURES

Two methods of treatment are available: (*a*) reduction and plaster, which is used only in patients aged under 50 years and when the fracture is not comminuted; (*b*) functional treatment, which is used in all other cases and is probably the best treatment for all split or crush fractures of the os calcis.

REDUCTION AND PLASTER — The heel is compressed from side to side either manually or with a special clamp. The posterior segment of the os calcis is pulled downwards or, if this proves ineffective, transfixed with a Steinmann pin and levered downwards.

An alternative method which is being tried is open reduction. The os calcis is exposed through a lateral incision. Its posterior portion is pulled downwards, the depressed segments of articular cartilage are elevated, and gaps in the bone are filled with cancellous bone chips.

If reduction has been achieved a below-knee plaster is applied with the foot plantigrade. The plaster is widely split and, when swelling has subsided, it is replaced by a complete plaster which is worn for a further 6 weeks. Exercises are encouraged within the plaster and more vigorously practised after its removal, but weight bearing is not permitted for 12 weeks after the injury.

FUNCTIONAL TREATMENT — Since correct reduction can rarely be held without leaving a painfully stiff foot, the fracture is disregarded. A crêpe bandage is applied, the foot elevated, and active exercises encouraged from the start. As soon as the patient is comfortable he gets up and takes weight, continuing active exercises.

With this method results, though far from good, are better than with plaster. About three-quarters of the patients thus treated return to full work in under 6 months.

TREATMENT OF CRUSH FRACTURES

Reduction is manifestly impossible. The fracture may be disregarded and the foot treated by the functional method described above. Alternatively the subtaloid joint may be arthrodesed.

COMPLICATIONS

Following split or crush fractures persistent pain may be felt, especially when walking on rough ground. The pain is usually localized immediately below the

lateral malleolus. If local anaesthetic injections or manipulation fail to provide relief, arthrodesis of the subtaloid joint sometimes proves necessary.

OTHER TARSAL INJURIES

A crushing force may fracture the scaphoid or cuboid bone or both, and may also cause mid-tarsal dislocation.

Dislocation or displacement is reduced under anaesthesia, and held in plaster for 6 weeks. The patient walks with an overboot. In the absence of displacement, neither reduction nor plaster is required.

INJURIES OF THE METATARSAL BONES

ROTATION INJURY

If the forefoot is violently twisted, tarsometatarsal dislocation may occur. The first metatarsal is either dislocated or fractured near its base; the outer metatarsal bones are fractured more distally. The injury is serious and may endanger the circulation of the foot.

Reduction is urgent and is maintained by a padded split plaster. The leg is kept elevated until it is certain that the circulation is satisfactory. After 3 weeks plaster is discarded, active exercises are started, and weight bearing is resumed at 6 weeks.

CRUSH INJURY

Any or all of the metatarsal bones may be fractured by crush injuries. Usually the metatarsal necks fracture and often the overlying skin is damaged. The orthodox treatment is to reduce the fractures by manipulation and to hold them in plaster for a few weeks.

The functional method is as follows. Unless displacement is gross, which is rare, it may be ignored. The leg is elevated and active movements started immediately. As soon as swelling has subsided, and the patient is comfortable, he is encouraged to walk normally. Mal-union rarely results in disability when mobility has been regained. Non-union does not occur.

TRACTION INJURY

Forced inversion of the foot may cause avulsion of the base of the fifth metatarsal. Displacement is slight and the fracture should be disregarded. If early activity is encouraged, and the patient walks as normally as possible in an ordinary shoe, full painless function is rapidly regained.

STRESS INJURY (MARCH FRACTURE)

In a young adult (often a recruit or a nurse) the foot may become painful after overuse. A tender lump is palpable just distal to the mid-shaft of a metatarsal bone. Usually the second metatarsal is affected, especially if it is much longer than an "atavistic" first metatarsal. The x-ray appearance may at first be normal or a mass

of callus may be seen; the fine transverse fracture may not be seen until several weeks have elapsed.

No displacement occurs and neither reduction nor splintage is necessary. The forefoot may be supported with Elastoplast and normal walking is encouraged; within a few weeks it becomes painless.

FRACTURED TOES

A heavy object falling on the toes may fracture phalanges. If the skin is broken it must be covered with a sterile dressing. The fracture is disregarded and the patient encouraged to walk in a suitably mutilated boot.

Suggestions for further reading

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